THE FEASIBILITY OF ELECTRICITY PRODUCTION USING WOOD AS AN ENERGY SOURCE IN TROUT LAKE AND GARDEN CREEK, ALBERTA

THE FEASIBILITY OF ELECTRICITY PRODUCTION USING WOOD AS AN ENERGY SOURCE IN TROUT LAKE AND GARDEN CREEK, ALBERTA

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EXECUTIVE SUMMARY

The study examines the feasibility of producing electricity from biomass using a steam boiler/steam (turbine) engine system for the communities of Trout Lake and Garden Creek.

The factors examined are as follows:

- Impact assessment on the communities.
- Biomass availability and alternate methods of harvesting the timber.
- Engineering analysis, system model, system efficiency, life cycle costing, operation and maintenance costs.
- Economic analysis of the steam boiler/steam engine (turbine) system and comparison to a comparable diesel generating system. Present value approach is used.
- Analysis of anticipated benefits, including increased employment, replacement of an oil dependent technology with a renewable source, and overall increase in the technical skills of the community.

Study conclusions and recommendations are the following:

- The quantity of Aspen/Poplar required for electrical conversion in a community consisting of two hundred people is very small and does not affect the environment adversely.
- A small sawmill steam boiler/steam engine system operating in a remote community with only two hundred inhabitants, with below average electrical power consumption, and no wood waste from a sawmill is not economically attractive. The very same system operating in a third world country would be economically attractive.
- Present value comparison between a diesel generating system vs. a small wood waste boiler/steam engine (turbine) system generating 150 kw of electricity had the following values and money allocation:

	Diesel System	Boiler/System Engine (Turbine) Chipping and Automatic Feed
Present Value	$1,970,000.00	$3,215,000.00
Manpower	5%	52%
Capital Cost:	8%	25%
Maintenance	6%	11%
Fuel Cost:	81%	12%

- Present value of the boiler steam engine (turbine) system using free biomass and no chipping was calculated to be $2,126,000.00.
- The high manpower cost of the small boiler/system (turbine) engine system stems from the Provincial regulations to continuously supervise the steam boiler.
- The study also encompassed a benefit/cost analysis. The analysis concluded that the introduction of a biomass conversion system into Trout Lake would be viable if diesel fuel escalated in price at a rate of 3% above inflation, within the context of the assumptions in the report.

FAISABILITÉ DE L'UTILISATION DE L'ÉNERGIE BIOMASSIQUE

POUR LA PRODUCTION D'ÉLECTRICITÉ À TROUT LAKE ET À GARDEN CREEK (ALBERTA)

Résumé

Cette étude envisage la possibilité de produire de l'électricité pour les collectivités de Trout Lake et Garden Creek à partir de la biomasse et ce, en utilisant une chaudière et une turbine à vapeur.

L'étude a porté sur les points suivants:

- Les répercussions sur la collectivité;
- La disponibilité de la biomasse et les méthodes de rechange pour le ramassage du bois;
- Les vérifications de l'ingénierie, la modélisation, l'efficacité du système, les coûts totaux, les coûts d'exploitation et d'entretien;
- L'analyse économique de l'utilisation d'un système chaudière-turbine à vapeur comparativement à un groupe électrogène diesel. On a tenu compte de la valeur actuelle du dollar dans cette analyse;
- L'analyse des bénéfices anticipés y compris l'augmentation des emplois, la substitution du pétrole par de l'énergie renouvelable et le développement des qualifications techniques de la collectivité, en général.

Les conclusions et les recommandations de l'étude sont les suivantes:

- La quantité de trembles et de peupliers nécessaire pour effectuer la conversion des systèmes électriques dans une collectivité ayant une population de 200 habitants est minime et n'a pas de répercussions néfastes sur l'environnement;
- L'utilisation d'un petit système chaudière-turbine à vapeur desservant une collectivité éloignée de 200 habitants seulement, dont la consommation d'énergie électrique ne dépasse pas la moyenne, et qui ne dispose pas de déchets de bois pour alimenter une scierie n'est pas intéressant du point de vue économique. Ce qui ne serait pas le cas dans un pays du Tiers-Monde, à supposer que le même système soit utilisé.
- La comparaison établie entre un groupe électrogène diesel et un petit système chaudière-turbine à vapeur produisant 150 kW d'électricité a donné les résultats suivants:

	Système diesel	Système chaudière-turbine à vapeur écaillage et alimentation automatique
Valeur actuelle	1 970 000 $	3 215 000 $
Main-d'oeuvre	5 %	52 %
Coûts en capital	8 %	25 %
Entretien	6 %	11 %
Coût du combustible	81 %	12 %

- On a établit la valeur actuelle de la chaudière-turbine à vapeur à 2 126 000 $ en se basant sur l'utilisation gratuite du combustible biomassique et en ne tenant pas compte de l'écaillage;

- Le coût élevé de la main-d'oeuvre nécessaire au fonctionnement d'un petit système chaudière-turbine à vapeur vient de ce que la province* exige la supervision continuelle de la chaudière à vapeur;

- L'étude comprend aussi une analyse coûts-avantages. L'analyse conclut que l'introduction d'un système de conversion de la biomasse à Trout Lake serait viable si le prix du combustible diesel suivait une progression de 3 % au-dessus du taux d'inflation, en tenant compte des hypothèses émises dans cette étude.

Cette étude a été entreprise pour les Affaires indiennes et du Nord Canada en faveur des collectivités de Trout Lake et de Garden Creek, à l'aide d'une subvention d'Énergie, Mines et Ressources Canada dans le cadre du Programme de démonstration dans les collectivités éloignées.

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* En vertu de la Loi sur les chaudières et appareils sous pression (traduction de "Boilers and Pressure Vessels Act") et des règlements de génie pris en vertu de cette Loi.

1.0 INTRODUCTION

1.1 STUDY OBJECTIVES

The object of this study is to undertake a comprehensive socio-economic and engineering feasibility analysis of using biomass electrical generation technologies for two communities in northern Alberta. The Department of Indian and Northern Affairs has sponsored the study which is being conducted through the "Remote Community Demonstration Program" of Energy, Mines and Resources Canada. Both DINA and EMR funded the study.

The two communities being examined are Trout Lake and Garden River. By conducting a site specific study, data taken from the two communities has enabled the project team to build conceptual models of the respective communities. In these models, the engineering feasibility of using gasification and steam generation conversion technologies has been assessed. Thus, the results of the study can be applied to remote communities with similar profiles.

1.2 METHODOLOGY

An extensive report of this nature involves multiple decision modes or options. In order to reflect this inherent procedure, the report has been written along the same dimensions that were used in the study methodology.

The first item examined was the general environment of remote northern communities in Alberta. Specifically,

provincial regulations were examined that regulate the production of electricity in these areas. By defining the regulatory role and its subsequent impacts, an evaluation of biomass conversions technologies was possible. Technologies that appeared feasible were then examined as per design and operational requirements. Thus, two feasible technologies were focussed on for in-depth analysis.

The second study area examined the current status of the two communities along the dimensions of community profiles, social acceptance and impact assessment. Although two technologies appeared feasible, implementation is dependent upon the respective communities accepting the project. During this phase, various agencies whose mandates encompassed these two communities were contacted along with community residents. Data gathering was undertaken by personal interviews, mail, telephone and on-site inspections.

The next stage in the study methodology encompassed the examination of biomass supply and harvesting methods. Without adequate supplies, no biomass technologies can become operable. Respective government and private agencies were contacted and the data was analyzed. Adequate access to biomass supplies were found to be present for one community, Trout Lake.

At this point, an in-depth value engineering analysis of the two biomass conversion technologies was undertaken. The technologies which appeared feasible were then costed and

examined per site location suitability, and present and future power demands.

The costs, capital and operational, were analyzed by various criteria. First, a present value calculation of the proposed system was performed, then compared against diesel technologies. Unit processes which may differ for other communities were then examined and analyzed in the same present value manner. This latter function provided a technological sensitivity analysis. Finally, a conceptual model of the community of Trout Lake was examined in a Benefit/Cost analysis.

This methodology was chosen in order to define the project feasibility, not in absolute terms, but rather in comparative analyses. By this process, plausible options and ranges which define the project's feasibility were examined in an environment that is subject to various scenarios.

2.0 REGULATORY AND TECHNICAL OVERVIEW

Before any comprehensive feasibility study can be conducted that examines replacing diesel generating plants with biomass conversion technologies, several parameters must be defined. These parameters include the regulatory landscape, the current power requirements of northern communities, feasible biomass conversion technologies, and finally, an examination of applicable operating codes and regulations. All of these aspects are discussed in this chapter with the intent of defining the general environment upon which the feasibility study is based.

2.1 THE HYDRO AND ELECTRIC ENERGY ACT

This Act is the primary act governing the production of electricity in Alberta. Its purposes, in general terms, are three-fold: first, to provide for an orderly development of the industry as reflected by market conditions; second, to ensure that safe and efficient practices are followed with respect to the general public and the environment; third, to record and disseminate information relating to the industry. The administration of this Act is undertaken by the Energy Resources Conservation Board (ERCB).

Before any construction or alteration to a power plant can commence, an application must be made to the ERCB. This

application process involves obtaining approval from the Lieutenant Governor in Council (Provincial Cabinet) and the Minister of Environment. The primary concern in assessing the application is whether the project is cost efficient. There is a section in the Act by which existing diesel generating plants in remote northern communities do not need cabinet authorization. This section, #9(2a) states cabinet authorization is not needed for power plants using fossil fuels which have a capacity of 15 Megawatts or less. In these cases, the ERCB has authorization for granting approval.

One other section which has implications on power plants located in remote northern communities is Section 19, Contingency Plans. This section states that the holder of an approval, permit or licence must have plans satisfactory to the Board which sets forth the methods by which the holder intends to avoid or minimize interruptions to the supply of electrical energy. In the case of remote northern communities, this stipulation has led to the installation of a complete back-up diesel generating system.

A demonstration project, such as the one being examined in this study, would be subject to examination in the same manner as any other application, with the addition that the net cost and dependability of the project would be assessed. The application would be filed by the current utility company responsible for the electricity generation and distribution

within the area. For the two communities being examined in this study, the utility company would be Alberta Power Limited. The application would contain all studies conducted for the proposed project.

2.2 ELECTRICITY GENERATION IN NORTHERN COMMUNITIES

Virtually all communities located in northern Alberta which are not connected to a major power grid have electricity generated by diesel powered plants. With the exception of several small communities, these plants are owned and operated by Alberta Power Limited. Provincial regulations stipulate that these plants must be capable of avoiding or minimizing any interruption in the supply of electrical energy. In practice, this stipulation has three major consequences: first, an entire back-up diesel generating unit is installed; second, adequate storage facilities for diesel fuel must be in place; third, plants are oversized to ensure that the peak demand for electricity can be met.

To illustrate how these three variables affect plant installations, Table 2-1 examines several communities in northern Alberta which use diesel generating plants. The information is taken from the report, "Energy Overview of Alberta's Remote Communities". Since fuel oil is obtained on tender and delivered to the site by the supplier, the methods of obtaining access to the respective communities are listed.

There is no limitation on the consumption of electricity except that space heating loads are not permitted.

Table 2-1 shows several items of interest. First, most diesel generating plants are between the sizes of 150 and 300 KW. At the extreme ranges, the minimum and maximum plant sizes are 50 and 800 KW respectively. In each location, should one unit fail, the back-up plant can meet peak demand. Plus, the accessibility of each community has a direct impact upon the capacity of diesel fuel stored at each location. Fort Chipewyan, Fox Lake and Chipewyan Lake each has storage capacities that meet or nearly meet annual diesel consumption. All three communities are accessible by road only in winter. This information reflects the stipulations in the Hydro and Electrical Energy Act referred to in section I of this chapter.

2.3 BIOMASS GENERATING SYSTEM OPTIONS

In this section of Chapter 2, various biomass conversion technologies will be evaluated. This assessment will be based upon the findings of the first two sections of this chapter, power requirements and dependability. Biomass generating systems must be sized between 50 and 500 Kilowatts to be applicable for most remote northern Alberta Communities. System dependability will be judged by the status of the technology, commercial and proven systems being preferred over systems with demonstration and pilot status. The information

TABLE 2-1: DIESEL GENERATING PLANT DATA, 1982

COMMUNITY	POPULATION	INSTALLED UNITS (KW)	PEAK DEMAND (KW)	ANNUAL GENERATION (MWH)	FUEL STORAGE (M^3)	USE (82)	ACCESS
Fort Chipewyan	1600	1x800 2x500 1x300	1020	3815	705	1171	Summer-air, barge winter-air, winter road
Fox Lake	750	2x250	200	778	396	345	summer-air winter- air, winter road
Jean d'Or Prairie	650	1x250 1x200	163	652	45	293	summer-air, all weather road winter-air, all weather road
Peerless Lake	204	2x150	102	350	45	159	summer-unimproved road winter-unimproved road
Trout Lake	203	2x150	84	229	45	157	summer-unimproved road winter-unimproved road
Chipewyan Lake	150	2x50	46	178	90	70	summer-air winter-air, winter road

SOURCE: Energy Overview Study of Alberta's Remote Communities, March 1983

used in this section on biomass conversion technologies has been taken from two ENFOR projects, C-185 and C-258.

2.3.1 Unit Processes

Biomass conversion technologies are complex systems involving a series of steps that yield a finished product from a raw material (e.g. electricity from biomass). In order to facilitate understanding, a methodology has been developed which analyzes the conversion system by examining each discreet process entity. This "building block" methodology is known as the unit processes approach. The following three definitions are relevant to understanding this methodology:

Unit Operation - a processing step involving a single principle;

Unit Process - an assembly of one or more unit operations that yield a required product;

System - an assembly of unit processes that yield a final product from a raw material.

This approach forms a methodology for assembling systems and for planning system optimization.

There are five basic unit processes in a biomass conversion system: first, fuel preparation and handling; second, primary conversion; third, modification and upgrading; fourth, secondary conversion. The fifth unit process, pollution control, can be applied anywhere among the other four depending upon the specific biomass conversion technology. Table 2-2 lists these unit processes along with sample definitions.

TABLE 2-2. DEFINITIONS OF UNIT PROCESSES

UNIT PROCESS	PROCESS DEFINITION
Fuel Preparation and Handling	
Storage and Reclamation	Weighing, unloading, movement and storage of forest biomass.
Handling	Conveying, metering, and feeding of forest biomass.
Comminution	Reduction in piece sizes of forest biomass by cutting, splitting, chipping, hammering, etc.
Classification	Segregation of a forest biomass fuel stream by particle size and material composition.
Mechanical Dewatering	Removal of water from forest biomass by evaporation.
Densification	Formation of reconstituted fuel products which have physical integrity and a higher density than the feedstock.
Primary Conversion by Direct Combustion	
Steam Generation	Production of steam using a biomass fuel in a boiler.
Hot Gas Generation	Production of hot combustion gases using a biomass fuel in a combustor.
Primary Conversion by Thermal, Chemical and Biological Methods	
Gasification	Production of hot or cold, clean or dirty fuel gas using a biomass fuel in a gasifier.
Pyrolysis	Production of char, tars and oils, and fuel gas by thermal decomposition of biomass, with the char being the primary product.

TABLE 2-2. (Continued)

UNIT PROCESS	PROCESS DEFINITION
Liquefaction	Production of a liquid product from biomass by direct application of heat and pressure, possibly in the presence of gases and catalysts.
Hydrolysis to Sugars - Pretreatment of Biomass - Acid Hydrolysis - Enzymatic Hydrolysis	Production of sugars (hexoses and pentoses) from biomass with the use of acids or enzymes.
Fermentation of Alcohols	Production of alcohols (mainly ethanol) from hexose and pentose sugars by fermentation.
Modification and Upgrading of Energy Forms	
Particulate Removal	Removal of particles from intermediate gas streams prior to processing.
Condensibles Removal	Removal of condensible material (and fine particles) from intermediate gas streams prior to processing.
Fuel and Synthesis Gas Upgrading - Sulphur and Carbon Dioxide Removal - Hydrogenation of Hydrocarbons - Carbon Monoxide Shift - Steam Reforming	Treatment of fuel gas or syngas to remove gaseous contaminants and adjust its composition prior to processing.
Alcohol Separation	Separation of ethanol and similar alcohols from water and chemical contaminants.
Pollution Control	
Particulate Control	Removal of particles from flue gases prior to atmospheric discharge.
Gaseous Contaminants Control - CO, NO_x, HC, SO_x, H_2S,	Removal of gaseous contaminants from flue gases prior to atmospheric discharge.

TABLE 2-2. (Continued)

UNIT PROCESS	PROCESS DEFINITION
Water Pollution Control - Pretreatment - Primary Treatment - Tertiary Treatment - Sludge Treatment	Removal of water pollutants from plant effluents prior to environmental discharge.
Solid Waste Disposal	Final disposal of solid wastes from a forest biomass processing plant.
Secondary Conversion of Energy Forms	
Steam Generation	Production of steam using hot combustion gases or fuel gas in a boiler.
Heat Exchangers - Gas/Oil - Gas/Air	Heating of a secondary working fluid (air, oil, etc.) by heat transfer from hot combustion gases.
Mechanical and Electrical Power - Steam Turbines - Internal Combustion Engines - Gas Turbines - Steam Engines	Production of mechanical and electrical power by a prime mover using a prepared working fluid or fuel.
Methanol Synthesis	Production of methanol from synthesis gas.

SOURCE: ENFOR PROJECT C-258, Volume II

2.3.2 Types of Biomass Generation Technologies

In total, there are seventeen conversion systems that can convert biomass to electricity. Although fuel preparation and handling may differ for each technology, the major differences between these systems exist from the primary conversion to the secondary conversion process stages.

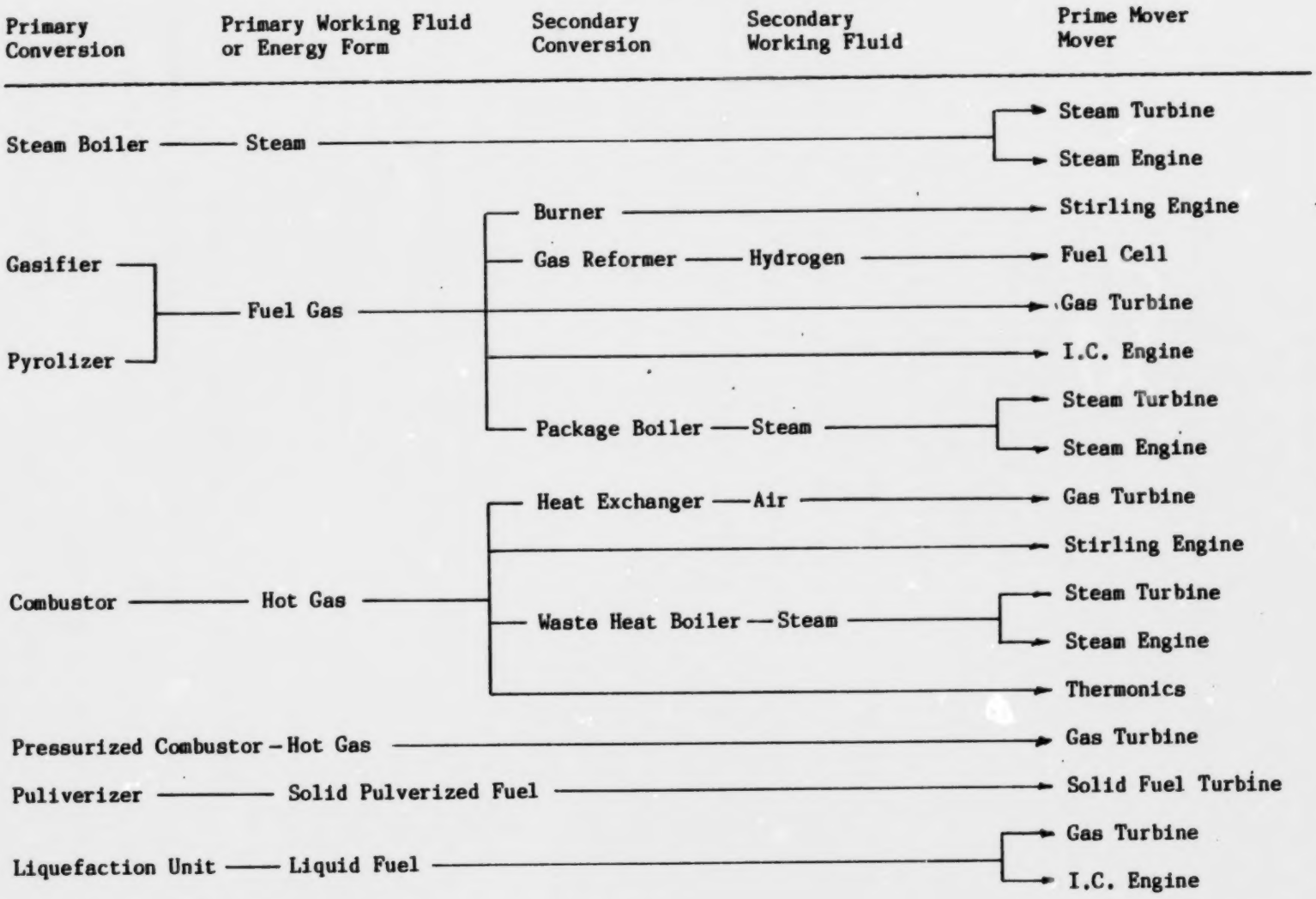
In the primary conversion process, either steam, hot gas, fuel gas, solid pulverized fuel, or liquid fuels are produced. These five primary working fluids or energy forms undergo various modification and upgrading and secondary conversion processes before they are converted through a prime mover to electricity. A prime mover can be defined as a turbine or internal combustion engine which drives an electrical generator.

Table 2-3 illustrates the seventeen different confugurations possible for biomass generation technologies. Several unit processes, pollution abatement and modification and upgrading, are not included in the table. The application of these two processes at various stages of a system are very much technology specific.

2.3.3 Biomass Generation Technology Evaluations

From prior sections in this chapter, two parameters have been defined which can be used to evaluate the seventeen biomass generation configurations. First, the systems must have a generating capacity between 50 and 500 KW.; second, to

TABLE 2-3: BIOMASS GENERATION TECHNOLOGIES



SOURCE: ENFOR Project C-185

meet ERCB requirements, they must be dependable. To meet this latter requirement, the systems are assessed according to their technological status, commercial and proven technologies being preferred over demonstration, pilot and unproven systems. Table 2-4 evaluates all seventeen systems discussed in section 2.3.2. It was proposed by the author and is based on conclusions drawn from ENFOR project C-185 more specifically table III-1 of the aforementioned project.

The results of the evaluation show that seven systems may be applicable to the requirements of remote northern communities. They are listed below by primary conversion unit and prime mover:

(1) steam boiler/steam turbine

(2) steam boiler/steam engine

(3) gasifier-pyrolyzer/internal combustion engine

(4) gasifier-pyrolyzer/steam turbine

(5) gasifier-pyrolyzer/steam engine

(6) combustor/steam turbine

(7) combustor/steam engine

The systems using a combustor have been rated as having poor potential since these systems often use a heat recovery boiler to generate steam for the steam turbine and engine. Thus, a larger system such as a gas turbine generating technology must be used which generates waste heat that can be used in a heat recovery boiler. As the power requirements of

TABLE 2-4: EVALUATION OF BIOMASS GENERATING SYSTEMS

SYSTEM (Primary conversion/ prime mover)	RATED OUTPUT (KW)	STATUS	BOILER CODE	APPLICABLE TO REMOTE COMMUNITIES
1. Steam boiler/steam turbine	300 KW plus	commercial	applicable	good potential
2. Steam boiler/steam engine	25-3000 KW	commercial	applicable	good potential
3. Gasifier-pyrolyzer/ stirling engine	40 KW and under	demonstration	N/A	N/A
4. Gasifier-pyrolyzer/ fuel cell	20 KW and under	unproven	N/A	N/A
5. Gasifier-pyrolyzer/ gas turbine	500 to 100,000 KW	unproven	N/A	N/A
6. Gasifier-pyrolyzer/ internal combustion engine	100 to 2000 KW	demonstration/ commercial	N/A	moderate potential
7. Gasifier-pyrolyzer steam turbine	300 to 8000 KW	demonstration/ commercial	applicable	poor potential
8. Gasifier-pyrolyzer/ steam engine	25 to 3000 KW	demonstration/ commercial	applicable	poor potential
9. Combustor/gas turbine	500 KW plus	pilot	applicable	N/A
10. Combustor/stirling engine	40 KW and under	demonstration	N/A	N/A
11. Combustor/thermonics	4 to 100,000 KW	unproven	N/A	N/A

TABLE 2-4: EVALUATION OF BIOMASS GENERATING SYSTEMS (Cont'd)

SYSTEM (Primary conversion/ prime mover)	RATED OUTPUT (KW)	STATUS	BOILER CODE	APPLICABLE TO REMOTE COMMUNITIES
12. Combustor/steam turnbine	300 to 11,000 KW	commercial	applicable	poor potential
13. Combustor/steam engine	25 to 3000 KW	demonstration/ commercial	applicable	poor potential
14. Pressurized combustor/ gas turbine	1000 KW	unproven	N/A	N/A
15. Pulverizer/solid fuel turbine	unknown	unproven	N/A	N/A
16. Liquifaction/ gas turbine	unknown	unproven	N/A	N/A
17. Liquifaction/ internal combustion engine	unknown	unproven	N/A	N/A

northern communities are small, it is assumed that insufficient waste heat would be produced for this configuration to apply. The use of a combustor to generate hot gas, then steam, would be less efficient than generating steam directly. This system would also most likely involve higher capital costs as a heat exchanger would have to be incorporated.

The final point made above has also been used in the evaluation of a gasifier-pyrolyzer, steam engine and turbine alternatives. Gasifiers are not as efficient as direct combustion boilers and add extra capital costs to the system.

The gasifier-pyrolizer internal combustion engine system has been rated as having moderate potential. The drawback in this configuration is the gasification system. Although several pilot demonstration projects have been conducted, this technology cannot be assessed as proven until several engineering malfunctions have been resolved. These problems are discussed further in this study.

Thus, only two systems in the final evaluation appear to have good potential - steam engines and turbines. These two systems are analyzed in detail in this study in order to determine whether their operating requirements, capital cost and socio-economic considerations in fact make these technologies attractive for remote northern communities.

2.4 OPERATIONAL CODES AND REGULATIONS

Besides the technical feasibility of gasification and steam generation systems, two other factors are examined in this overview. The first item relates to the fifth unit process, pollution control. The other factor relates to the manpower requirements of the respective technologies.

2.4.1 The Clean Air and Clean Water Acts

When an application is forwarded to the ERCB, part of the approval process involves a scrutiny of the project by Alberta Environment. For small projects of the size being examined in this study, direct participation by Alberta Environment is not a necessary prerequisite. However, if the ERCB feels their scrutiny is warranted, the Department will examine the proposal to see if it meets the specifications stated in the Clean Air and Clean Water Acts.

There are three sections in the Clean Air (Maximum Levels) Regulations that pertain to biomass conversion technologies. They are as follows:

Part 1: Maximum Permissible Concentration of Air Contaminants in the Ambient Air.

Part 2: Visible Emissions.

Part 3: Particulate Emissions.

Of particular interest to Alberta Environment, are the particulate and visible emissions resulting from burning

biomass. Therefore, the primary conversion unit process must be coupled with a pollution control unit process. Plus, depending upon the design of a steam boiler system, boiler blowdown may warrant examination by the Enforcement Division of the Air Quality Branch.

Typically, the Clean Water Branch, as with the Clean Air Branch, does not become involved with the application for approval through the ERCB, but this condition again depends upon the technology used. For example, a letter of exemption may be issued for a closed steam generation system which is of insiginificant impact or concern, which means that the system must be designed within certain parameters. Consider that a closed system involves a condensor that must be installed in the conversion system. Should a body of water be used to cool the steam, the general rule of thumb is that the temperature increase of the receiving body does not increase more than three degrees celsius in an identified mixing zone. If this condition is not met, then there is reason for Alberta Environment to look at the proposal. An open steam generation system would most likely be examined by the Department during the approval process.

2.4.2 Manpower Requirements

Each of the two general technologies targetted in 2.3.3 have similarities regarding their operational manpower requirements. The easiest way to differentiate these requirements

from other technologies is to examine their respective supervision requirements to see if they are general or continuous. General supervision means that the plant is visited occasionally (three times a day) to ensure the plant is functioning properly. Continuous supervision means the plant is manned every hour that it is in operation. Table 2-5 examines the supervision requirements of the technologies being examined in this study versus the conventional diesel powered internal combustion engine system.

TABLE 2-5: Supervision Requirements for Various Electrical Generation Technologies.

TECHNOLOGY	SUPERVISION REQUIREMENTS
Diesel powered internal combustion engine	general
Wood gas powered internal combustion engine	general
Steam generation using a steam turbine or steam engine	continuous for plants with boiler ratings above 250 KW.

The operation of steam boilers is regulated by the Boilers and Pressure Vessels Act and the subsequent Engineers' regulations. In the Act, the definition of a power plant is given as:

(1) any one or more boilers in which steam or other vapour is generated at more than 103 KPa;

(2) any one or more boilers containing liquid and having a working pressure exceeding 1,100 KPa and a temperature exceeding 121 degrees celsius;

(3) combination of the above.

A power plant using a boiler of less than 10KW (1Bhp) is exempt.

The Engineers' Regulations state the specific certificate required for both general and continuous supervision of a range of boiler plant ratings. These certificates are summarized in Table 2-6. The boiler plant ratings being examined in this study in relation to the power requirements of Trout Lake and Garden River are between 250 and 1000 KW. This means that plants located in these communities must be under general supervision of an individual with a Fourth Class Certificate; and that they must be manned continuously with someone with a Fireman's rating.

TABLE 2-6: NECESSARY CERTIFICATES FOR SPECIFIC BOILER PLANT RATINGS

Power Plant Boiler Ratings KW (Bhp)	Minimum Certificate Required for:	
	General Supervision	Continuous Supervision
Above 10,000 KW (1020 Bhp)	First Class	Second Class
Not exceeding 10,000 KW (1020 Bhp)	Second Class	Third Class
Not exceeding 5,000 KW (510 Bhp)	Third Class	Fourth Class
Not exceeding 1,000 KW (102 Bhp)	Fourth Class	Fireman's
Not exceeding 500 KW (51 Bhp)	Fireman's	Fireman's
Not exceeding 250 KW (25 Bhp)	Special Boiler Operator's	Not required
Not exceeding 20 KW (2 Bhp)	Exempt from regulations	

Source: Alberta Boilers Branch & Boilers and Pressure Vessels Act - Engineer's Regulations

Technical Note: boiler power rated @ $1m^2$ heating surface - 10 kilowatts boiler power.

3.0 COMMUNITY PROFILES

Through discussions with area residents, government authorities and other knowledgeable individuals, it appears that the majority of remote communities identified in the Energy Overview Study of Alberta's Remote Communities have similar characteristics. In most cases, the majority of homes are owned. Most family structures have two parents as the head of the household and almost half of the population is either 17 years of age or younger. The services which appear to be mentioned as most needing improvement are fire protection and emergency medical services. Social assistance is considered by residents as being good for the people of various communities.

These trends are supported by recent surveys conducted by the Alberta Lake Lands Family and Community Services Office in Slave Lake. In total, four communities were surveyed: Chipewyan, Trout, Loon and Peerless Lakes. Survey results may be found in Appendix II. Besides the trends cited above, one further trend is worthy of noting: in every community, the strongest response and most often mentioned problem was the lack of local employment. According to the local office for Social Services and Community Health for these communities, the average wage is $1200 per month and the average size of social assistance per family is $800 to $850 per month. Therefore, employment opportunities in these communities appear to be supported by all involved with community affairs.

The two communities being examined in this study, Trout Lake and Garden River, are in many ways similar but yet have characteristics which are opposite. The original rational for choosing these two communities was based upon differing methods of supplying biomass for the plant. In Trout Lake, local residents would harvest and transport the biomass. In Garden River, waste from logging operations would be used.

As shown in the following community profiles, the community services and attitudes of the residents are similar. However, their respective accessabilities, communication systems, and orders of government having jurisdiction over the communities are different.

3.1 TROUT LAKE

Trout Lake is a Metis hamlet located on the south shore of Graham Lake approximately 250 kilometres north of Lesser Slave Lake (see figures 3-1 and 3-2). Its current population is estimated to be 227. Approximately 60% of the habitants are of Treaty status, mostly belonging to the Big Stone Band. Half the population are seventeen years of age or younger. Trout Lake is accessible year-round over a 100 kilometre road through Peerless Lake from Highway 67 at Red Earth.

The community is unincorporated and part of Improvement District 17 managed from High Prairie. The local government consists of a community association. The community is also serviced by the Alberta Offices of Family and Community Support

FIGURE 3-1

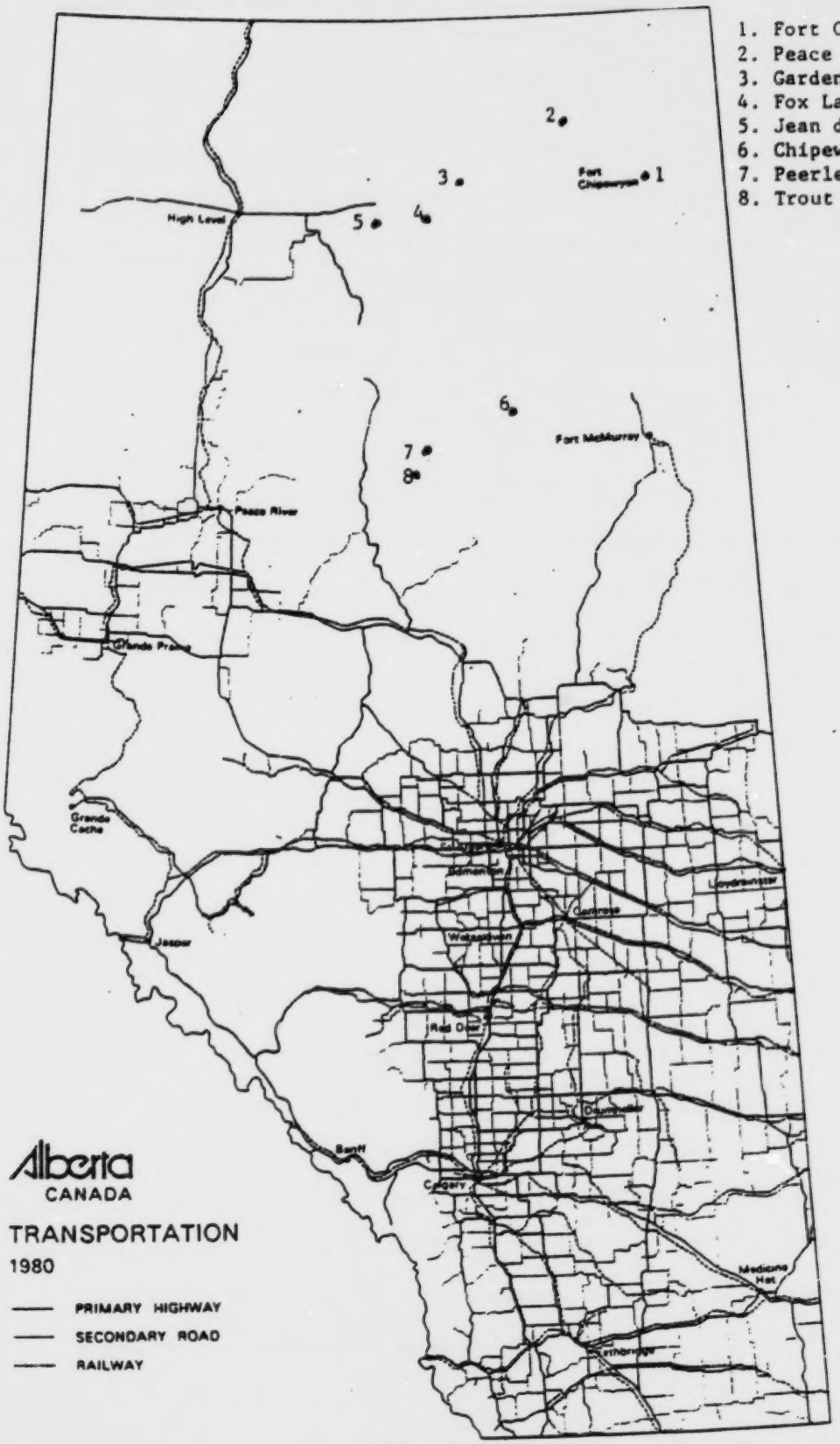
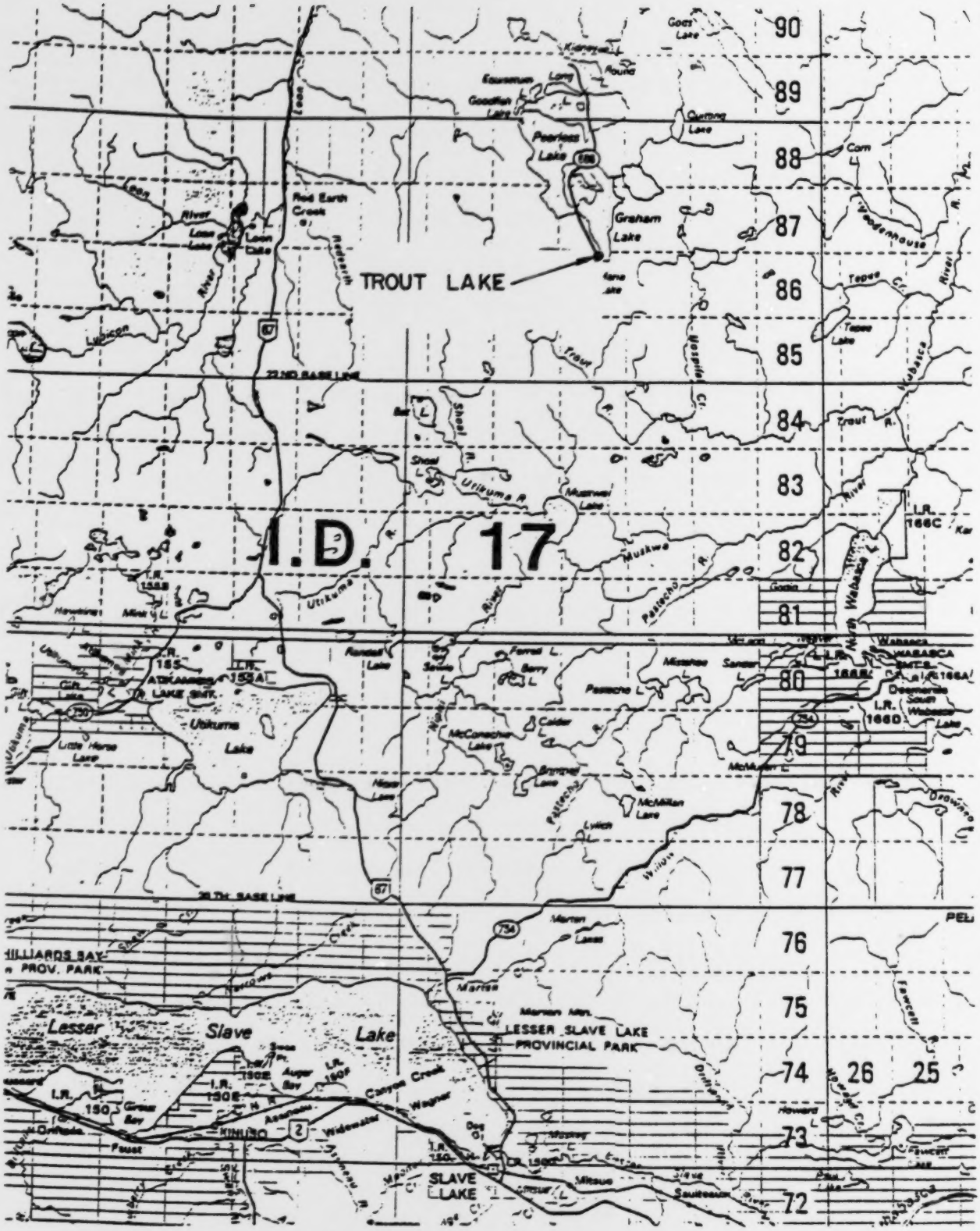

1. Fort Chipewyan
2. Peace Point
3. Garden Creek
4. Fox Lake
5. Jean d'Or Prairi
6. Chipewyan Lake
7. Peerless Lake
8. Trout Lake
Fort Chipewyan
High Level
Fort McMurray
Peace River
Grande Prairie
Grande Cache
Jasper
Edmonton
Lloydminster
Camrose
Wetaskiwin
Red Deer
Banff
Calgary
Medicine Hat
Lethbridge
Alberta
CANADA
TRANSPORTATION
1980
PRIMARY HIGHWAY
SECONDARY ROAD
RAILWAY

FIGURE 3-2


TROUT LAKE
I.D. 17
Lesser Slave Lake
LESSER SLAVE LAKE PROVINCIAL PARK
SLAVE LAKE
KINUSO
Utikuma Lake
Graham Lake
Pearless Lake
Red Earth Creek
Loon Lake
Trout R.
Utikuma R.
Muskwa R.
Pasquia R.
Wabasca R.
Calder
McMillan Lake
Marten Lake
Marten Mtn.
Canyon Creek
Wagner
Widewater
Assumption
Faust
Driftpile
Howard
Fawcett
Sawridge
Peavine
Sucker Creek
Atikameg
Lake Sinc.
Little Horse Lake
Goose Lake
Goodfish Lake
Equesmun Lake
Long Lake
Kinnaird Lake
Quatre Lake
Corn
Woodenhouse
Trout Lake
Shoal L.
Mistawasis Lake
Muskwa Lake
Passacho L.
Ferrel L.
Berry L.
Messaho
Sawan
Wabasca
Desmarais
South Wabasca Lake
McMillan L.
Lytton
Williams
Drawsinger
Howse Lake
Bruneau Lake
McCorochie Lake
Hawkins
Mink L.
Rondel Lake
Big Hay Section
Sheal L.
Bar L.
Lubicon
Lubicon L.
Loon R.
Red R.
Hospital Cr.
Wabasca L.
Godin
Mistassiniy L.
Mistassiniy R.
Mistassiniy Cr.
Mistassiniy Lake
Mistassiniy River
Mistassiniy Creek

Services and Social Services and Community Health, both with offices located in Slave Lake. Alberta Transportation located at Red Earth maintains the roads and the airport. Table 3-1 lists the services available in the community.

It appears the biggest employer in the community is the school operated by Northlands School Division. Other major occupations include the Opportunity Corp Program operated by the Northern Alberta Development Council and trapping. A multitude of individual occupations exist from bookkeeper, priest to postmaster. Occasional employment is found in the oil industry located around Red Earth or from fire fighting as needed. From the survey conducted by Lakelands Family and Community Support Services, 97% of respondents stated that there were not enough job opportunities available in the community. As mentioned earlier, the average monthly wage in these communities is approximately $1200 per household. The average social assistance per family is $800 per month.

Several improvements are currently being undertaken in the community by the Improvement District. A fire hall is near completion lacking a concrete floor and electrical wiring. A new central well is in operation which provides treated water to the majority of the inhabitants. Possible future improvements to the community include a laundromat and a lighted airport. This last improvement reflects the demand by local residents to provide better emergency medical services.

TABLE 3-1: COMMUNITY SERVICES - TROUT LAKE

HAMLET:	Population: 227
WATER:	Supply - Graham Lake, Trout River, central well Distribution - none Treatment - central well
SEWER:	Collection - none Disposal - septic tank, privies, lagoon for the school
WASTE DISPOSAL:	Collection - none Modified landfill
UTILITIES:	Electricity - residential and commercial Space Heating - wood, fuel oil, propane
COMMUNICATIONS:	Telephone - private lines Radio - CKYL, Peace River TV - reception approximately 8 months per year - restricted to non-daylight hours - signal picked up from Martin Mt. repeater Mail - local post office
TRANSPORTATION:	Main Access - Secondary #686 (gravel) Internal Roads - gravel Bus - none Truck - none Rail - none Air - turf airstrip, nearest paved and lighted Slave Lake (250 KM).
HEALTH SERVICES:	Hospital - none, nearest at Slave Lake Medical - visiting doctor from Slave Lake - flies in every second Thursday Public Health - visiting nurse from Wabasca - flies in on alternate weeks than Doctor Ground Ambulance - none, nearest Red Earth
EDUCATION:	Schools - one (1-11), no current enrollment in grade 12 - Alberta Vocational College, current enrollment 12 - Community Library - none

TABLE 3-1. (Continued)

RECREATION:	Facilities - skating rink, ball diamonds, school facilities
	Access to - Graham and Peerless Lakes
POLICE PROTECTION:	None resident, served by Red Earth R.C.M.P.
FIRE PROTECTION:	Fire Hall - currently being built
LOCAL GOVERNMENT:	Area represented on I.D. #17 Advisory Council; Community Association
OTHER GOVERNMENT OFFICES:	Alberta Opportunity Corps
ACCOMMODATION: (food, lodging)	None, nearest facilities at Red Earth
CHURCH/MISSIONS:	Catholic and Protestant mission
COMMERCIAL SERVICES:	Store, Post Office

There are approximately 45 residential dwellings in the community with most of the space heating requirements being met with wood stoves. It is estimated that each residence consumes between 10 to 15 cords annually. Most of the homes have television even though reception is limited. Over half the homes have fridges and/or freezers. Only a limited number of dwellings have ranges or washing machines. A substantial number of homes have no running water, and haul water from the central well.

The housing stock in the community is relatively mixed. Ten log homes have been built in recent years; another twelve frame dwellings have been built by the Opportunity Corps who are currently completing construction on four other homes. An additional twelve houses will be built by the Corps over the next three years. Photographs of the community are included in Appendix III. A new school was recently completed for Northlands School Division. The Alberta Opportunity Corps has a new building. No other major construction has taken place in the community.

Communication with the community is relatively easy. Direct long distance telephone and mail services are available in the community.

In general, the residents of Trout Lake enjoy its peaceful location. Community attributes mentioned by inhabitants include the easy access to the wilderness, its scenic location, the quiet and the people. No significant changes are anticipated for the community in the future. Population growth is expected to increase at the current rate of 4% per annum. The addition of a gas station in the community would be welcome. The possibility of new oil fields being developed near Peerless Lake, 30 kilometres north, is expected to have minimal impact on the community.

3.2 GARDEN RIVER

Garden River sometimes known as Garden Creek, is an isolated Native settlement located on the north shore of the Peace River just inside Wood Buffalo National Park, approximately 200 air kilometres east of High Level, Alberta (see figure 3-3). The population of the community is currently estimated at 200 to 250 inhabitants. It is the third community of the Little Red River Band causing the population to fluctuate as inhabitants move between communities. Approximately 90% of the inhabitants are of Treaty status. The majority of inhabitants are families with young children. The community is accessible by a logging road from High Level except during freeze-up and break-up periods.

Since the community is located in a national park, the federal government has jurisdiction over the community. Two federal departments share responsibilities within the community, Parks Canada and the Department of Indian and Northern Affairs. The Parks Canada office is located in Fort Smith. DINA has offices that deal with the community in High Level and Edmonton. Local government consists of an elected member on the Little Red River Band Council. The band manager for the Little Red Band is located in Jean d'or Prairie. The logging road is maintained by Canadian Forest Products Ltd. from High Level. Table 3-2 lists the services available in the community.

TABLE 3-2: COMMUNITY SERVICES - GARDEN RIVER

SETTLEMENT:	Population - 200-250
WATER:	Supply - 2 wells, Peace River, Garden Creek Distribution - institutional (school), Commercial (laundromat). Treatment - planned
SEWER:	Collection - none Disposal - privies, septic tanks, lagoon for the school
WASTE DISPOSAL:	Collection - none Cribbed pit central incinerator
UTILITIES:	Electricity - residential and commercial Space Heating - wood, propane, diesel
COMMUNICATIONS:	Telephone - toll station at the school Radio - CKYL, Peace River, CBC (poor unless booster used). TV - CBC (poor) Local Newspaper - Band newsletter Mail - no post office (informal delivery via store owner)
TRANSPORTATION:	Main Access - winter road, 70 KM to highway #58 Internal Roads - gravel Bus - none Truck - none Rail - none Air - turf airstrip, nearest paved and lighted Fort Vermilion (160 air km)
HEALTH SERVICES:	Hospital - none, nearest Fort Vermilion Medical - visiting Doctor once a week from Ft. Vermilion Public Health - Federal Health Clinic (staffed by one community health worker who is not a registered nurse). Ground Ambulance - Vehicle at nursing station (nearest regular services from Jean D'or Prairie).

TABLE 3-2. (Continued)

EDUCATION:	Schools - (K-9), (10-12) going out Other - Continuing Education Class (adult upgrading 12 - funded by Fairview College and Canada Manpower) Community Library - none, just school
RECREATION:	Facilities - skating rink (outdoor), Community Hall, gym in school
POLICE PROTECTION:	None resident, served by Fort Vermilion R.C.M.P. (by air)
FIRE PROTECTION:	None
LOCAL GOVERNMENT:	One elected member on Little Red River Band Council
OTHER GOVERNMENT OFFICES:	Public Health Clinic
ACCOMODATION: (food/lodging)	None, nearest Fort Vermilion or High Level
CHURCHES/MISSIONS:	Catholic
COMMERCIAL SERVICES:	Store, laundromat

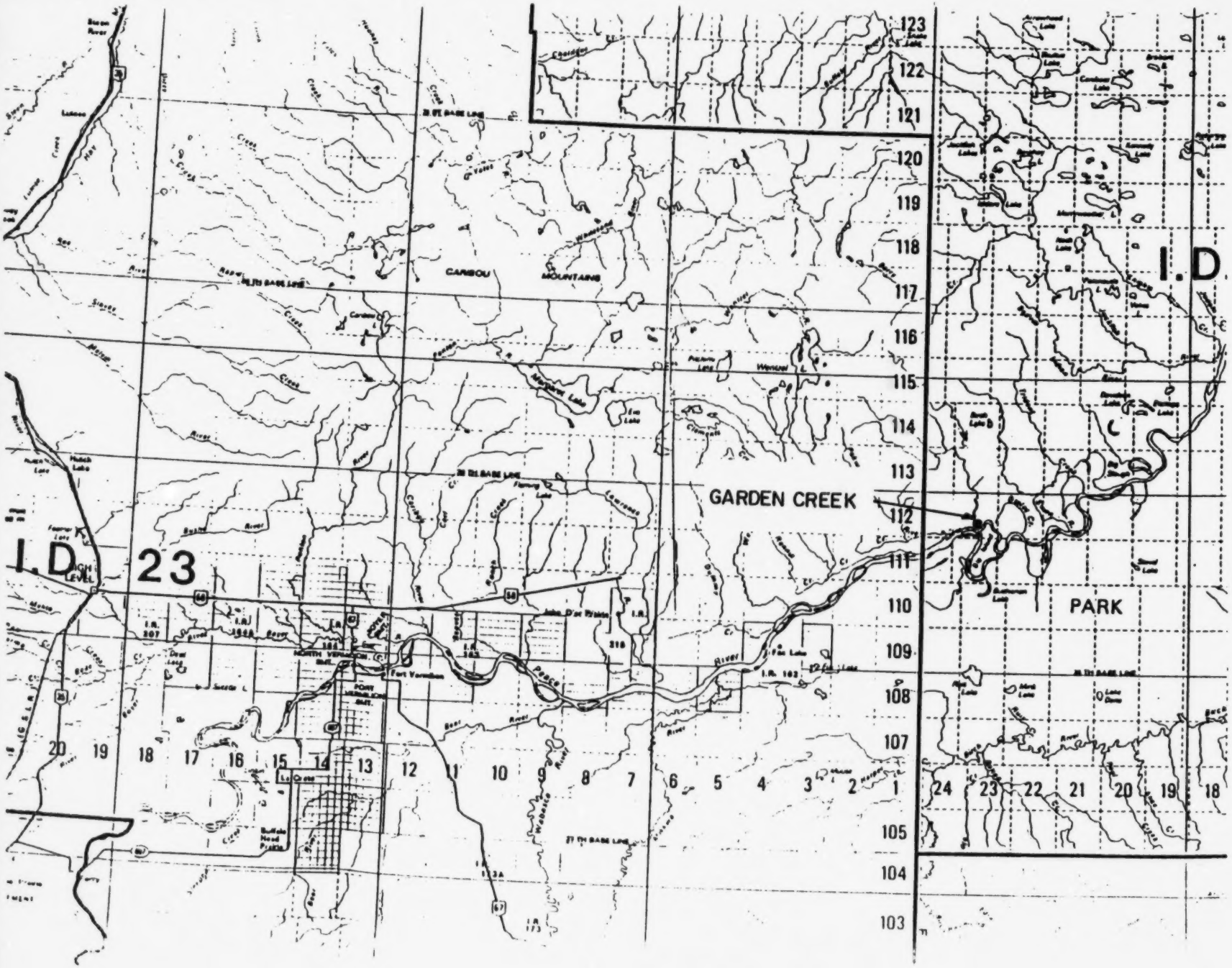

I.D
23
HIGH LEVEL
GARDEN CREEK
I.D
PARK
CARIBOU MOUNTAINS
Fort Vermilion
PEACE RIVER
123
122
121
120
119
118
117
116
115
114
113
112
111
110
109
108
107
105
104
103
20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
24 23 22 21 20 19 18

FIGURE 3-3

Many employment opportunities in the community are seasonal. They range from logging, trapping, hunting to fire fighting. The school which is operated by Northlands School Division combined with the Community Vocational College, offers some employment. Individual occupations such as a storekeeper, and community health worker can also be found. Social assistance provides significant income to community residents especially during the off seasons of spring and summer. Again, the desire for more permanent employment opportunities were stressed.

A new school is being completed in the community. It is expected to open some time in the winter of 1984/85. The Department of Indian and Northern Affairs is currently examining alternate methods of supplying water to the community as the flow rates in the central well supplying the new school and laundromat are inadequate. No new projects are known to be planned although the local band councillor stated a five-year plan for the community is being developed with a fire hall being a prime consideration.

There are approximately 45 residential dwellings in the community. With the exception of the mobile homes used for the teacherages, all the homes are of log construction. They tend to be small with an approximate floor area of 600 to 800 square feet. All are heated by wood, consuming less than 8 to 10 cords annually per household. Relatively few electrical

appliances are used as power has only been available for one year. Almost all residents must haul or have water delivered by truck. Photographs of the community are contained in Appendix III.

Communication with the community is difficult. A toll station at the school may be contacted through the Peace River mobile operator, but it is impossible to determine who will answer the phone. There is no formal mail service to the community although the storekeeper will transfer mail to and from the community when obtaining supplies from High Level and Fort Vermilion.

The community is situated in a very scenic location. Very few visitors enter the park through Garden River as the main access is through Fort Smith. Although logging operations are currently conducted in the Park, they are expected to be curtailed in 10 years. Plus, there is hope on the part of Parks Canada to have the community and surrounding area excised from the park in the next few years. The current National Parks Act is not designed to accommodate land uses such as Garden River. Therefore, the exact future of the community is uncertain. The growth of the community is now restricted by Parks Canada. To obtain a Licence of Occupation for any dwelling requires Cabinet approval which can take one to two years to obtain. If the community is removed from the Park, it still remains uncertain how the community will change.

4.0 BIOMASS POTENTIAL SUPPLY

Many small communities are supplied with electrical power produced by stationer diesel type generators. Fuel for the generators is transported to these communities by truck. Access is generally over relatively poor road conditions and is also constrained through seasonal fluctuations which regularly prohibits vehicle access.

This section of the study examines wood supply opportunities for the two communities selected for the study, namely Trout Lake and Garden River, Alberta.

These settlements are not unique in their location. Band reserves are isolated and are heavily dependent upon hydro carbon based fuels, which are costly. They also experience high levels of unemployment. The surrounding forests amongst which they live can supply all the energy needs required and also a potential means of gainful employment that can be employed within the region.

The volume of fuel required is estimated at 625 cords per year (Section 5.2) for generating power for community use. This volume will need to be increased depending on what fuel preparation will be required. In anticipation of this, the study assumes that 1,000 cords of wood per year will be required.

4.1 TROUT LAKE COMMUNITY

4.1.1 Location

Trout Lake Community is situated at the southern tip of Graham Lake, Township 86, Range 04, West of the 5th meridian in the Province of Alberta. It is located approximately in the centre of Timber Management Unit S11.

4.1.2 Forest Cover

Generally, the community is surrounded by accessible stands of timber, the predominant species being Trembling Aspen and this predominance and lack of commercial use, would make it the most suitable species to harvest for fuel. In addition, the rapid growth of the species compared to coniferous types, make it most desirable in order to maintain a sustained yield over time, in close proximity to the community, thus minimizing transportation costs.

The coniferous species that are available, consist of White Spruce, Black Spruce and some Lodgepole Pine, all of which are in the minority with respect to available volumes. The White Spruce is small in total volume of the area and is such that it can be utilized commercially, e.g. for lumber production, and should be reserved for such. Black Spruce stands are poor, small, scrubby type trees, which would be suitable for use as fuel but would not be less economical to log due to its low timber volume per hectare compared to Aspen.

In considering Aspen as the prime fuel source, Phase III inventory data prepared by the Alberta Forest Service and by site inspection, defines the Aspen stands as follows:

- Density (by crown) 50% to 70% - medium to fairly dense stands
- Height - Class I - 6.1 to 12.0 metre Class II - 12.1 to 18.0 metre the average being closer to 12.0 metre.
- Origin - Stands are largely in the juvenile stage, in the 30 to 50 year age group.
- Site - The site is classed as medium, rolling country combining muskeg and dryer type ridges. No serious problems with terrain exist from a logging operation standpoint, provided logging plans are designed correctly.
- Volumes - Based on previous experiences, gross volumes of Aspen contained in the stands, excluding branches, is estimated at 180 m^3/hectare. Approx. 30 cords/ha. solid wood) based on clear cutting.

4.1.3 Wood Supply and Alternatives

There are no sources of waste wood from wood products manufacturing facilities in the area. The nearest operation is located at Red Earth, approximately 60 miles by road from Trout Lake. Hauling costs for such waste would be high and supply would be interrupted through seasonal fluctuations and the reliability of continuing sawmill operations.

With the predominance of Aspen in the area, the assurance of fuel supply would be through using the standing timber as fuel supply which would involve logging approximately 40 hectares per year (approximately 100 acres), including for roads and understocked areas. This supply could be obtained within the Township on a sustained yield basis providing 30 to 50 year rotation of growth.

There is no competition for the use of Aspen from this particular area and it is unlikely that any will be in the immediate future, due to lack of commercial interests. The nearest facility that utilizes Aspen is located at Slave Lake, a considerable distance away. Therefore, the wood supply would not be impaired by demands of other users.

4.1.4 Government Timber Tenures

To ensure a continuous supply of raw material to the energy conversion unit, tenure must be established by the user. As the area considered is on Crown land, the administering authority for timber use is by the Provincial Government through the Forests Act and associated regulations.

In order to acquire Crown timber, an application is made to the Minister of Energy and Natural Resources defining the timber needs. Crown timber may be disposed of by the Minister in one or more of the following ways:

(a) through a forest management agreement

(b) through the sale of timber quota certificates and issuance of a timber licence.

(c) through the issuance of a timber permit

In view of the relatively limited quantity of timber required to supply the project, a timber quota or permit would be the recommended method of tenure.

The Minister may allocate a timber quota which will define the volume or area of deciduous timber the quota holder may harvest. This authorization will specify the location, time and amount of forest land on which the timber would be harvested.

Subject to compliance with regulations or other conditions the Minister may impose, a timber quota certificate would entitle the quota holder to harvest timber for a specified period not exceeding 20 years, normally in 5-year increments.

The quota holder shall be issued a timber licence provided that:

(a) they provide a financial deposit with the Minister to ensure performance of the licence obligations

(b) comply with all other licence requirements

(c) pay the assessed fees and costs in relation to cruising and issue of the licence

Other obligations, including reforestation requirements, will be written into the agreement, which the quota holder will be required to meet in order to sustain supply.

The standard costs associated for a deciduous timber quota, that is used for fuel wood, would be:

Performance Deposit	$ 500.00
Royalty (Timber Dues)	.15/m3
Reforestation levy	.10/m^3

A portion of the S11 Management Unit is declared as a Forest Recreation Area. This area is located to the north of Trout Lake in TWP 88, Rge 4, Wo/5km. It would not present any problems to the sustained wood supply required for this project.

4.2 GARDEN RIVER

4.2.1 Location

The community of Garden River is located in the South Western corner of Wood Buffalo National Park in TWP 112, Rge 23/24, west of the 4th meridian.

4.2.2 Forest Cover

With the location of the community being within a National Park, and consequently subject to regulations and policy covering resource extraction within National Park boundaries, access to timber supply is severely constrained.

Normally, commercial timber extraction within National Park boundaries is extremely limited. However, in this instance, exceptions were made in 1957 which allowed for extracting commercial timber for supply of building and mining materials in Uranium City.

Certain timber allocations were made to allow timber manufacturers to produce materials demanded by the mine and residential developments.

Subsequent events led to the majority of these timber licences being acquired by Swanson Lumber Company of High Level, which was the predecessor company of the now Canadian Forest Products Company Limited. The timber leases for the coniferous species presently operated by Canadian Forest Products Limited are to be terminated by year 2001 and it is unlikely that they will be renewed:

(a) because of National Park policy and

(b) the lack of commercially viable stands of timber

The existing timber tenures specifies that rights to harvesting timber is for mature and overmature Spruce timber in the region with a mandate to harvest a minimum of 10,000m^3 per year. With the exception of one block of coniferous timber to the east of the community, Canfor logging plans indicate that all the merchantable timber will be removed by the end of the tenure period.

Removal of the mature/overmature timber is considered as an alternative to loss of the timber through fire or insect loss. As such, the area is not considered to maintain a sustained timber yield over time and any regeneration is through natural means only. The requirement placed on the logging company is to ensure revegetation takes place to maintain an environment more in keeping with natural events.

As such, a continuous timber supply from coniferous species from the logging areas cannot be considered to provide a regular source of fuel.

One source of biomass that can be considered is by collecting residues from present logging operations namely tree tops, branches and unmerchantable trees. Technically this is a feasible situation but, economically unsound. Past experiences and some studies conducted reveal that the cost of such residual recovery is quite high, being between twice and three times the cost of harvesting the whole tree. One advantage of collecting such logging residue is that it can be done by hand, therefore, labour intensive and requires a minimum of equipment.

Our estimate of the costs of material from logging residue landed at the community would be in the order of $40 to $45/m^3 green volume. Costs of obtaining the raw material will escalate rapidly as the haul distance increases proportionally

to the volume of residue recoverable from each logged over site.

Figure 4-1 gives a visual indication of the portions of components available from typical Alberta stands, e.g. in the case of White Spruce - the species logged off, stem volume represents 82% of the total biomass by volume. This varies slightly depending upon the top diameter of the tree at which it is utilized.

4.2.3 Alternative Fuel Supplies

The area surrounding the community has extensive standard Aspen/Poplar with Black Spruce on the muskeg flats. It would be a least cost choice to harvest the Aspen/Poplar similar to that suggested for the Trout Lake area. It is estimated that the costs of harvesting would be similar in both cases.

There are no viable sources of wood waste fuel from lumbering operations in the immediate area that could sustain a supply of fuel over time.

4.2.4 Timber Tenures

National Parks Policy is such that it does not encourage or allow for natural resource extraction within the Park boundaries. A major policy change will be required to allow the timber supply be provided from within the Park, or the designated areas will have to be deleted from the Park and

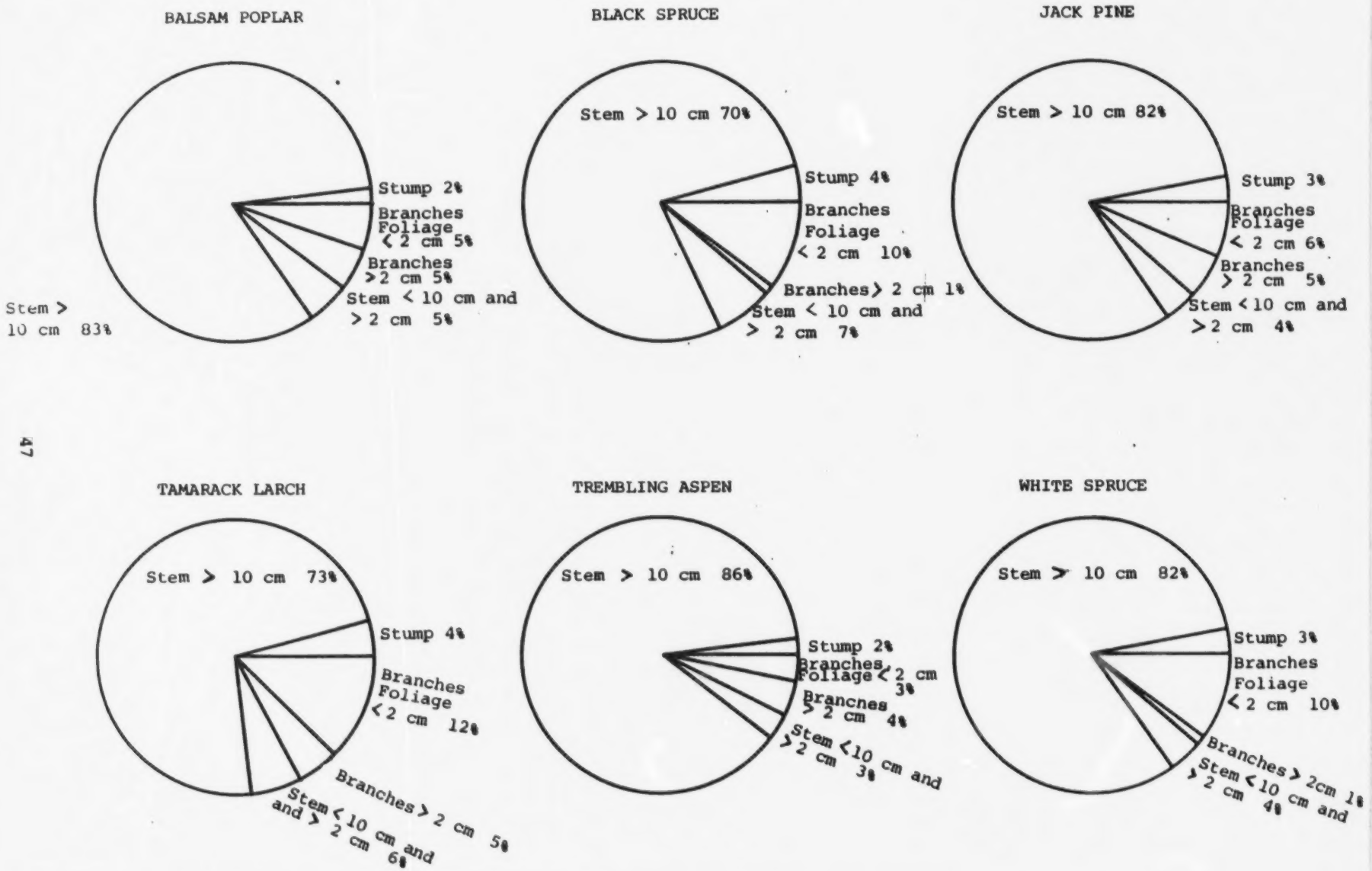


Figure 4-1: Pie diagrams for the stem and nonstem components of the six tree species.

Source: Biomass Equations for six major tree species of the Northwest Territories. T. Singh, Information Report NOR-X-257, Northern Forest Research Centre.

be subject to Provincial or Federal Forest Management plans through the respective Forest Services.

Discussion with the Superintendent of Wood Buffalo National Park has concluded that there are no timber reserves within the Park which can be used for the biomass plant.

4.3 LOGGING ALTERNATIVES

Consider alternatives with capital costs and operating costs for the following:

- Non-mechanized falling, skidding and hauling
- Mechanized skidding and hauling.

4.3.1 Non-Mechanized Logging

This approach to obtain adequate fuel supply is one which is fairly labour intensive. The volume of material required would be compatible with the availability of manpower and services. Because of the nature of the terrain, a non-mechanized system using hand falling of timber, skidding logs to landings by horses and horsedrawn carts and sleighs for hauling would be technically feasible provided skidding and hauling distances are kept to a minimum. In addition, the logging and hauling season would be extended over that for a mechanized system where frozen ground conditions are needed for heavy logging type equipment to be used.

The estimate considers a representative logging operation as one unit and consequently production levels and

allows for an operating time span of 150 days per year basis. A typical logging operation would consist of the following configuration:

- one faller with chainsaw, to fall, limb and buck into short logs
- 3 single horse skidders including tracers, 1 man
- 1 man stacking/loading with horse assisted loading
- 2 - 1 man, 2 horsedrawn cart/sleigh for hauling to mill site

The logging plans would be such that skidding distances from main haul loads would be kept as short as possible with landing/loading stations located alongside main roads. This configuration should be anticipated to produce 10 cords per day (24 m^3 solid wood) average and vary somewhat depending on logging site and timber volume per acre.

Capital Costs

Estimated capital costs per logging site:

3 chainsaws, files, gas containers	$ 1,000	
5 horses suitably trained	$ 5,000	
Skidder traces, 3 plus 1 spare	$ 2,000	
2 Hauling carts	$ 1,000	
2 Hauling sleighs	$ 1,000	
A frame loading equipment	$ 1,000	
Contingency	$ 1,000	
	$ 12,000	
Performance guarantee	$ 500	$ 12,500

Operating Costs - 10 cords (24 m^3 solid wood) per day, per m^3

5 man crew @ $60/day	$ 300	
Chainsaw supplies/day	25	
Equipment maintenance	20	
Horse, feed, vet fees, 7 horses $ 4.00	28	
	$373	$ 15.54
Stumpage/royalty		.05
Holding & Protection Charges		.10
Reforestation		.10
Skidways and landing developments		.25
Supervision and Overhead		5.00
		$21.04/$m^3$

4.3.2 Mechanized Logging

There are several approaches to consider in a mechanized logging operation. Principally three considerations are made as follows:

(a) utilization of available manpower in the area to form a logging operation

(b) to arrange for independent logging contractor

(c) utilizing a clear cutting, total tree recovery concept

In all cases of mechanized logging operations, logging hauling season would be restricted to winter time operations when operations would not be impeded with soft ground conditions and to minimize environmental impacts on ground disturbance.

Consider

(a) With the relative small volume of timber required, a logging configuration would consist of hand falling,

skidding with small (D6 type) caterpillar tread tractor - also used for road and landing clearing and a self loading logging truck. Trees would be skidded full length onto landings, bucked into short lengths, say 2 - 4 m, and loaded on truck with a self-contained clam shell loader.

Estimated Capital Cost:

3 chainsaws and supplies	$ 1,000
1 Tractor (2nd hand)	$ 40,000
Chokers	$ 2,500
Self-loading truck (2nd hand)	$ 40,000
	$ 83,500

Operating Costs - Production 30 cords/day (72 m^3/day)

1 Faller @ $60/day	$ 60	
Power saw rental & supplies	$ 10	
Skidder inc. operator @ $45/hr. inc.	$ 360	
Truck @ $40/hr. (incl. operator)	$ 320	
Contigency	$ 25	
	$ 775	$10.76
Roads/Skid Trail/landings		$ 3.00
Supervision		$ 1.66
Stumpage/holding & protection charges and reforestation		$ .25
TOTAL:		$15.67/$m^3$

(b) Independent Contractor Logging

The relatively small volume of timber required to be logged does not make it attractive to bring an independent contractor in from outside the area.

Generally, the contractor would be concerned with logging the total volume of timber at one visit to keep the costs of moving in and moving out equipment as low as possible.

Total annual wood requirements would be logged and delivered to the mill site and utilized as required by the energy unit. One advantage of this method of providing the wood supply is that it would allow the timber to lose moisture content prior to its use.

Estimate costs of timber landed at the log yard under this proposal would be $\$20.00/m^3$, which includes "moving in/ moving out" allowance and crew camp costs.

(c) Mechanized Clear Cut Falling

A study conducted by The Coban Institute of Edmonton under the Enfor programme, Project P163, examined a proposal to clear cut Aspen stands with mechanical means. A Dika side cutter mounted on a caterpillar tractor was used for felling timber and this process was compared to a hand falling situation.

The report shows that 85% to 90% of the total amount of biomass was available for utilization under the test conditions. It states that this biomass recover is substantially more than that recoverable under normal logging practices. In addition, landed log costs by the mechanical falling operation were 1/3 to 1/2 the cost of the hand falling system.

This system of fuel wood acquisition is most suitable to large volumes required and would not be very suitable for the volumes required in this study. The utilization of the equipment to produce 1,000 cords per year would not be justifiable.

4.4 ASPEN - CHEMICAL ANALYSIS

In considering Aspen as the prime source of fuel (the analysis conducted under the Coban study) it was found that the variations in the Aspen stands was relatively minor and were as follows:

Moisture content	46.8%
Bulk density	0.161 g/ml
Heat Value	19.2×10^3 KJ/kg

The relationship of green weight to dry weight is indicated on Table 4-1 (Singh 1984).

One analysis on Poplar stands reported in Energy and Chemicals from wood by Alberta Energy and Natural Resources gives the following analysis for Poplar.

Density 0.3684 kg/L at 48% m.c.w.b

Chemical analysis % by weight

C	H	S	N	O	Ash
51.8	6.3	0	0	41.6	0.3

* NOTE: The method of calculating moisture content was:

$$\frac{\text{Green weight - Dry Weight}}{\text{Green Weight}}$$

* SEE APPENDIX NOTES

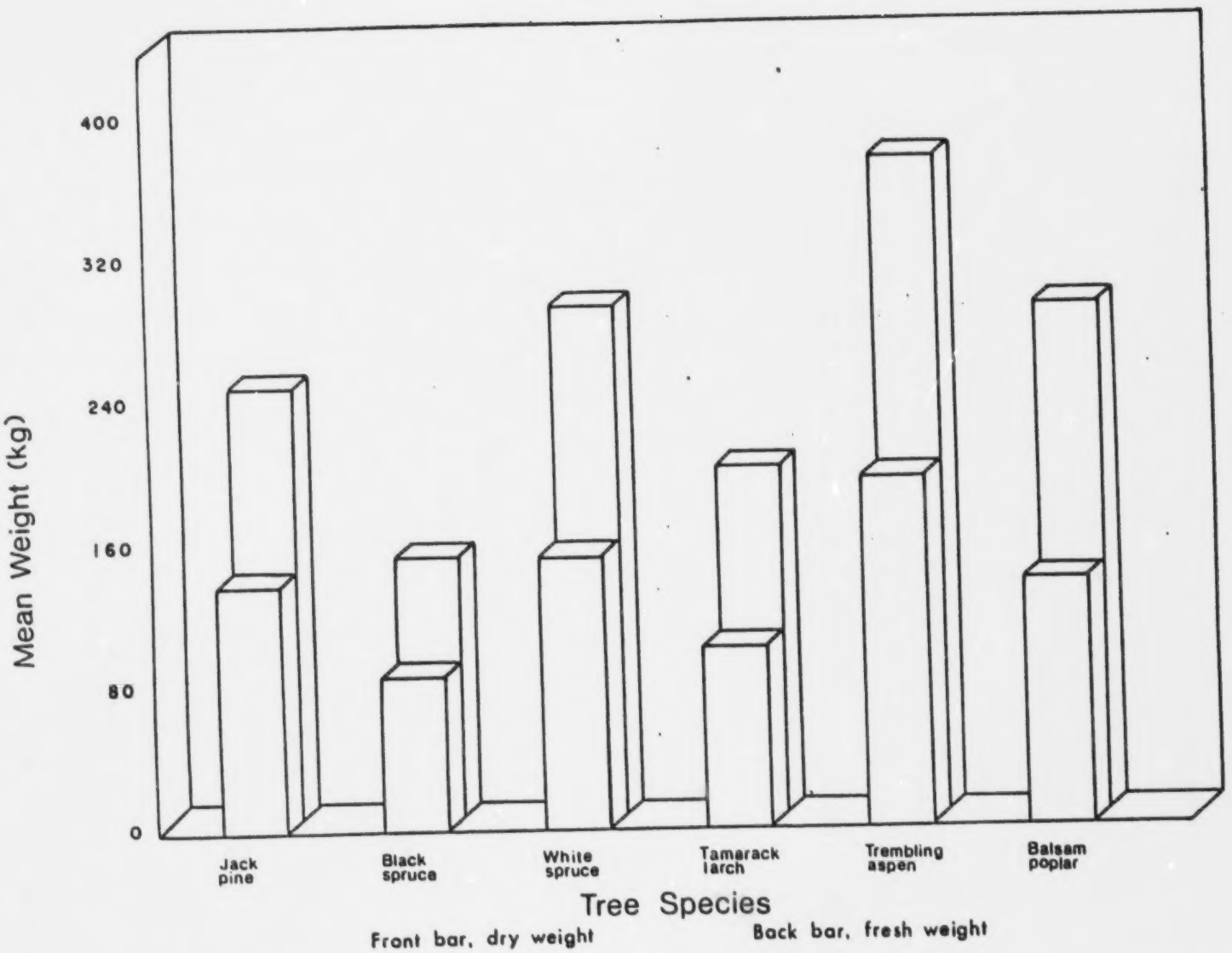


Table 4-1 Fresh and dry weight biomass of the six tree species.

4.5 HARVESTING PLANS

Timber management plans would be required and best designed to achieve specific objectives, namely:

- deliver wood fuel to the plant at minimum cost over the long term
- provide maximum employment to Band members and be compatible with the abilities of the Band members
- encourage self reliance
- allow for minimum capital requirements for equipment and development costs
- provide training skills which could lead to employment of Band members in other areas

Harvesting plans would be structured to meet these objectives and through the use of minimum heavy equipment, the lay out of logging blocks would be such as to take advantage of stand locations near to presently defined access routes.

Much of the logging work including skid trail development can be done by hand.

4.6 FUEL PREPARATION

4.6.1 Introduction

Generally, wood waste energy conversion systems require the fuel to be of uniform size to allow the proper mixing of air and wood for optimum combustion.

In considering the requirements of this study in general, the fuel preparation must be accomplished with a low capital and operating cost basis, be simple to operate and still be effective. Manufacturers of wood waste energy systems appear to have found that wood chips, similar to those produced for pulp mills, provide the proper trade-off between bulk density and air flow resistance. For these reasons, a chipping type operation is to be considered for this wood waste energy system.

The study by B.H. Levelton & Associates, recommends that a mobile type plant be used that employs a V-drum chipper, as this type of chipper requires less horsepower and less maintenance than a disc or drum type chipper. Low knife maintenance is particularly desirable in this type of operation.

A fine particle size material energy system is not recommended in this application as the material required will entail further processing and consequently increase capital and operating costs.

To keep the horsepower requirements low on the chipper the size of the piece of tree fed to the chipper must be kept small. Therefore, a hydraulically operated splitter would be used to enable large diameter (larger than 6") trees to be split into smaller segments.

To maintain a fairly consistent size of wood chips fed to the combustion unit, would require installation of a simple scalping type screen. The installation should be designed to allow for screening of chips which could be stockpiled on the ground and remove contaminants such as rocks, etc. from the fuel furnish.

The wood chips would be conveyed to a small storage bunker and fed from the bunker with a variable speed device such as a screw conveyor in order to regulate fuel supply to the demand of the energy unit.

4.6.2 Fuel Moisture Content

It is desirable to utilize a fuel conversion unit that would be capable of accepting the wood furnish without the need to reduce its moisture content. From a fuel preparation point of view, this would keep the system as simple as possible.

In recommending the use of Aspen/Poplar as the fuel wood for the energy system, note should be made of its relatively high moisture content in the fresh cut, green stage. A recent study done under the Enfor programme for a location in the Slave Lake Forest, shows that the moisture content dry basis was approximately 80% and some indications of being over 100%.

* Moisture content percentage = $\frac{\text{green weight-dry weight}}{\text{dry weight}}$

* SEE APPENDIX II NOTES

To reduce this moisture content, the raw material could be logged and piled to allow for air drying prior to use in the fuel system, though this is of limited value in the winter time. Timber must be cut in the summer for use in the winter to have a positive effect.

4.6.3 Log Storage

To allow for seasonal fluctuations in logging operations, a log storage area is required. The storage area would serve to dry the wood for an entire year prior to usage. The strategy is to cut the wood in winter (120 days/year logging), then stockpile it for a year prior to usage. The storage area required or the log yard would be approximately 2 hectares in size and is required to be on fairly good ground conditions.

Short logs would be delivered to the log yard, scaled for royalty assessments and stockpiled with a small tractor unit equipped with log forks.

On demand of fuel needs, logs would be recovered from the yard, transported with the front end loader to the chipping system.

4.6.4 Fuel Preparation and Log Yard Cost Estimate Capital Costs

- 40 hp tractor with front end forks and bucket	$ 30,000
- hydraulic log splitter, 4 axe, 15 hp	$ 10,000
- chipper infeed conveyor, hydraulic 5 hp 15 ft	$ 6,000
- pallman V drum chipper, 30 hp	$ 40,000
- chip conveyor, 30 ft 10 hp	$ 8,000
- scalping screen, 5 hp	$ 5,000
- fuel bin, 10 tonne	$ 10,000
- fuel metering screw conveyor, 5 hp (costed in the price of boiler Section 6.2.1)	
- shed roof structures over equipment (costed as building cost Section 6.2.1.2)	
TOTAL:	$109,000
- chipper knife grinder, babitt jigs etc., 2 hp	$ 6,000
TOTAL	$115,000

Operating Costs

The log yard/chipping operating can be accomplished with 1 person plus some assistance to maintain the equipment and grind and set chipper knives. Annual operating costs are estimates as follows.

- Labour - per annum	$ 20,000
- Fuel, oil and lubrication	$ 8,000
- Maintenance Supplies	$ 5,000
- Knives	$ 5,000
- Miscellaneous supplies	$ 3,000
- Contigency	$ 4,000
TOTAL:	$ 45,000 per year

5.0 ENGINEERING ANALYSIS

5.1 ELECTRICAL ENERGY PROJECTION - TROUT LAKE & GARDEN RIVER

There are many factors to consider in trying to project future electrical energy requirements for communities such as Trout Lake and Garden River. Considerations include:

(1) community affluence and acceptance of technology

(2) natural population growth rates;

(3) sensitivity to utility company charges;

(4) industrial and institutional growth requirements;

(5) the present ratio of electrical community requirements in comparison with requirements of the populous urban areas

Inhabitants of remote communities such as Trout Lake and Garden River are not affluent. The use of electricity is restricted to major appliances such as refrigerators and T.V.'s and possibly freezers. Purchase of appliances are not undertaken all at once, but rather in progressive steps as finances allow. Consider the average monthly wage of $1200 per family for inhabitants of like communities and one can conceptualize relatively lower consumption rates than urban counterparts.

In fact, statistics support the latter premise. The average Alberta household consumes approximately 600 KWH per month. In Trout Lake, the average is 277 KWH/month; in Garden River 211 KWH/month. Consumption is primarily due to lighting

and appliances across the province as electricity is rarely used for space heating in any location.

Currently, Alberta Power services 55 customers in Trout Lake and 26 customers in Garden River. Given that there are approximately 45 residential dwellings in both Garden River and Trout Lake which contain equal populations, it appears that in the future, the growth rate of power consumption in Garden River will surpass that of Trout Lake. This higher growth rate is also substantiated since Garden River has only had residential electrical service available to the community for the past year.

Past records indicate a very large electrical consumption annual growth rate for remote communities in Alberta. These growth rates are illustrated in Table 5-1; Alberta Power projects a much slower growth rate for both communities as exhibited in Tables 5-2 and 5-3. These growth rates are projected based on discussion with community residents and applicable public and private agencies.

The historical population growth rate in Trout Lake is approximately 4%. This figure would imply that electrical consumption would double in approximately 70/4 = 17.5 years (all other factors excluded). The 70/4 was derived from the formula:

$$T = \frac{\ln 2}{G} = \frac{70}{G}$$

where T = doubling time
G = the growth rate expressed as a percentage
$\ln 2$ = 69.3 ≈ 70

The ten year projection by Alberta Power has a 50 MWH increase every two years that would result in a doubling of power requirements in 22 years.

TABLE 5-1 ANNUAL ELECTRICITY GENERATION, MWH

1978-1983

Community*	1978	1979	1980	1981	1982	Average Annual Growth 1978-1982, %
Fort Chipewyan	2,632	2,788	2,906	3,295	3,815	9.7
Chipewyan Lake	100	130	149	149	178	15.5
Fox Lake	552	610	677	719	778	9.0
Jean d'Or Prairie	434	521	517	566	652	10.7
Peerless Lake	128	164	181	266	350**	28.6
Trout Lake	131	145	194	215	229	15.0

Source: Alberta Power Limited

** Generation appears inconsistent with fuel consumption

(Current Alberta Power projections show a much slower growth for both Trout Lake and Garden Creek. See TABLE 5-2 and TABLE 5-3)

TABLE 5-2: POWER PROJECTIONS - TROUT LAKE

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Anticipated Energy Requirements MWh	350	380	405	430	450	475	495	510	530	540
Anticipated Peak Load (KW)	110	120	130	135	140	150	155	160	170	170
Anticipated Diesel fuel Liters Consumed*	152	162	167	190	196	158	165	170	192	200

* in thousands.

TABLE 5-3: POWER PROJECTIONS - GARDEN CREEK

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Anticipated Energy Requirements MWh	440	465	495	505	510	510	515	515	520	530
Peak Demand Load (KW)	120	125	135	135	140	140	140	140	140	145

Calculating the expected growth rate using the Alberta Power projection:

$$G = \frac{70}{\#\text{of years to double}} = 3.2\%$$

Although it is difficult to accurately determine the growth rate of Garden River's population, similar calculations for Garden River project a power growth rate of less than 3.2%.

In conclusion, it is believed that the true electrical consumption growth rate for both communities lies between 4% and the past record of 15% for Trout Lake. This rate will probably continue at 15% for the next few years then taper down to 4%. For power consumption rates to equal Alberta averages implies that the affluence of the communities must equal those of their urban counterparts. Recent examples of remote communities providing services such as sewer and water have shown that the local population is very slow in connecting to these respective services. The primary reason for this trend is lack of available finances to purchase the appliances and equipment necessary to make the connection operable. In other words, assume a doubling of electrical generation for Trout Lake in 70/9 = 13 years. Garden River should experience faster growth. Electrical growth rates will probably be in the range of 9% on average.

Data is not available to accurately conduct a load management study. The study team anticipated providing base load requirements with a biomass conversion system coupled with a small diesel generator to help provide peak loads. A study which would define hourly and daily loads is strongly recommended. As far as examining inappropriate end uses for

residential electricity consumption, the current use of this energy form is too low to warrant in-depth examination. For all intents and purposes, there are no inappropriate end uses.

5.2 BIOMASS REQUIREMENTS

The supply of biomass to meet energy requirements is dependent upon three factors: firstly, the overall efficiency of the biomass to electricity conversion system; secondly, the energy content of the biomass taking into consideration subsequent moisture content; thirdly, the power requirement of remote northern communities. The following discussion examines these three factors and combines them in an order of magnitude analysis:

For the purpose of this analysis, a system efficiency of 20% is used. In order to define the volume of biomass required, the energy content of oven dry, air dry and freshly harvested (green) aspen/poplar must be specified. These figures and other related data are given in Table 5-4. The weight and energy content per cord are calculated from the density, moisture content and volume per cord. The energy per cord can also be calculated by taking the higher heating value of the biomass and multiplying it by the weight. For aspen/poplar with moisture contents (wet basis) of 48%, 12% and 0%, the energy contents are 9MJ, 17.5MJ and 19.4MJ per kilogram respectfully (see figure 5-1). These figures equate to 17.5,

TABLE 5-4: PROPERTIES OF ASPEN & POPLAR

Elemental Composition - Wood (wt %)

- carbon 51.8%
- hydrogen 6.3%
- oxygen 41.6%
- ash 0.3%

Higher Heating Value - (MJ/Kg, dry basis)

- wood: 19.4 MJ/Kg
- bark: 20.5 MJ/Kg

Densities - (ovendry condition)

- basic: 370 ODKg/M^3 (per green volume, 48% moisture content wet basis)*
- air dry 410 ODKg/m^3 (per volume at 12% moisture content, wet basis)
- oven-dry 420 ODKg/m^3 (per dry volume, 0% moisture content)

Energy Content

Density	Higher Heating Value	GJ/m^3	GJ/cord solid**	Kg/m^3	Kg/cord solid
basic	19.4 MJ/Kg	7.18	17.3	806	1940
air-dry	19.4	7.95	19.2	476	1150
oven-dry	19.4	8.15	19.6	420	1010

* According to the report by Woodland resources, one cord of solid wood weighs 2407 Kg green. This weight equates to a moisture content of 58% wet basis. Levelton states that freshly cut timber can have a moisture content between 40% and 76%.

** 1 solid cord of wood = 2.41 m^3, 1 stacked cord = 3.62 m^3

Source: ENFOR Project C-258

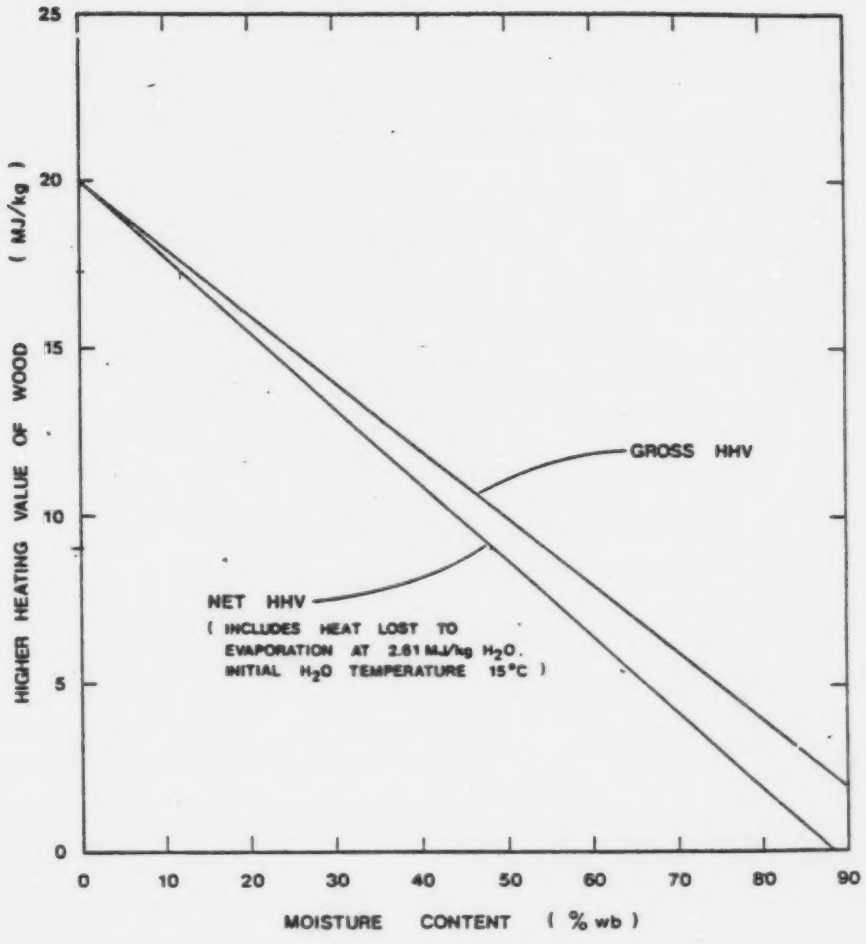


FIGURE 5-1: EFFECT OF MOISTURE CONTENT ON HIGHER HEATING VALUE OF WOOD ON THE BASIS OF WET WEIGHT

SOURCE: ENFOR PROJECT C-258

19.6 and 20.2 GJ per cord. These figures are within 4% of the value derived by the other calculations.

The final factor to be examined is the power requirements of the communities in question. This calculation will use Trout Lake as a data base. From the data given in section 5.1, the energy requirement for the community for the entire year of 1985 is expected to be 350 MWH. Using the 13 year doubling time and assuming that figure can be used as an average over 20 years, the power requirements will be in the order of 700 MWH annually.

The system conversion efficiencies utilizing a steam turbine and steam engine are 21% and 17% respectively. These figures equate to an average annual biomass requirement of 625 cords (12% mcwb) for a steam turbine and 770 for a steam engine. In 1985, 315 or 390 cords would be needed respectively.

5.3 GASIFICATION

In section 2.3 of this report, gasification and pyrolysis have been assessed as one system. In actuality, gasification is a pyrolysis process. To differentiate between the two, Levelton distinguishes the processes according to their respective main products. Gasification maximizes fuel gas, while pyrolysis produces solid char.

In a gasification process, biomass is heated in the absence of oxygen causing a sequence of reactions which produce

a low BTU value heating gas. This gas is fired in an internal combustion engine which drives a generator to produce electricty.

Gasifiers are classified according to the motion of the fuel bed. They are of either fixed or stirred/fluid bed design. Fixed bed gasifiers are further classified according the the relative direction of the fuel bed and injected gas regents (i.e. updraft or downdraft). Figures 5-2, 5-3, and 5-4 illustrate the three types of gasifiers. Table 5-5 contains a summary of their operating performance.

The current status of gasificatiom technology does not exhibit the reliability necessary for generating electricity in remote northern communities.

As discussed in the regulatory overview, the ERCB states that the generation technology must operate with minimal interruption. The balance of the discussion in this section will focus upon recent demonstrations of gasification technology.

During 1979 and 1980, Saskatchewan Power Corporation conducted a series of experimental gasifier runs under the project name of the Hudson Bay Wood Gasifier. The intent of these trials was to evaluate the performance of the unit and its potential for commercial application. The unit used was a 250 KW B.C. Research fluidized bed wood gasifier. Its designed

TABLE 5-5: TYPICAL OPERATING PERFORMANCE AND COSTS FOR GASIFIERS

CRITERIA	UPDRAFT	DOWNDRAFT	FLUID-BED
State of Development	Demonstration	Commercial	Demonstration
Fuel: Size (cm)	0.6 - 5	1- 10	<5
4 Moisture Content (%, wb)	25 - 50	<30	<50
Output Capacity (GJ/h)[a]	up to 30	up to 15	up to 150
Turndown	3 - 4 : 1	3 : 1	2.5 : 1
Cold Gas Conversion Efficiency (%)[a]	70 - 75	70 - 85	70 - 80
Air/Fuel Ration (kg/kg)	1.5 - 2.0	1 - 2	2 - 3
Gas HHV (MJ/m^3) Higher heating value	4.4 - 6.5	4.4 - 6.5	4.4 - 6.5
Exit Gas Temperature (°C)	80 - 95	350 - 600	760
Condensibles:			
Yield			
H_2O (kg/kg wet feed)	0.4	N/A	0.3 - 0.5
Tar (kg/kg dry feed	0.05	very low	0.02
Tar HHV (MJ/kg)	27.9	N/A	23.3
Particle Loading (g/m^3, 15°C, 101 kPa)	N/A	N/A	N/A
Equipment Cost ($/GJ/h)	25 GJ/h - (U.S.) 30,000	3 GJ/h - (U.S.) 52,000 13 GJ/h - (U.S.) 25,000	63 GJ/h - 13,000

[a] Based on higher heating value of fuel gas at 101 kPa and 15°C.

SOURCE: ENFOR Project C-185

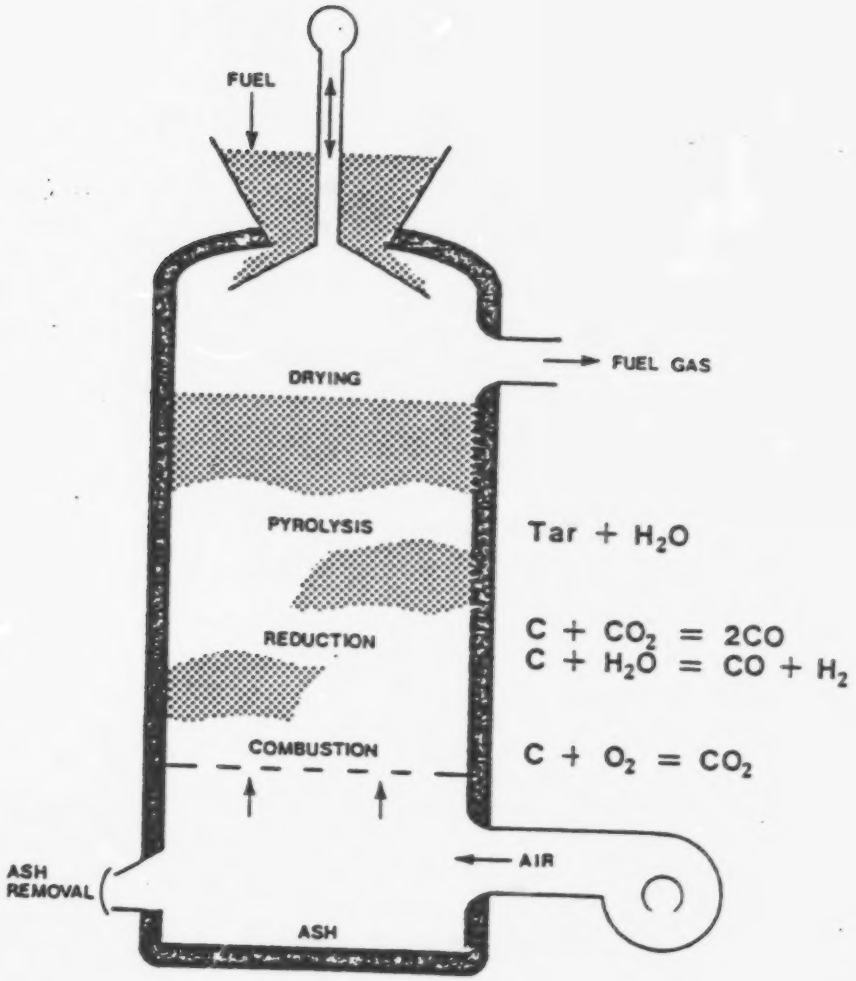


FIGURE 5-2: UPDRAFT GASIFIER

SOURCE: ENFOR PROJECT C-258

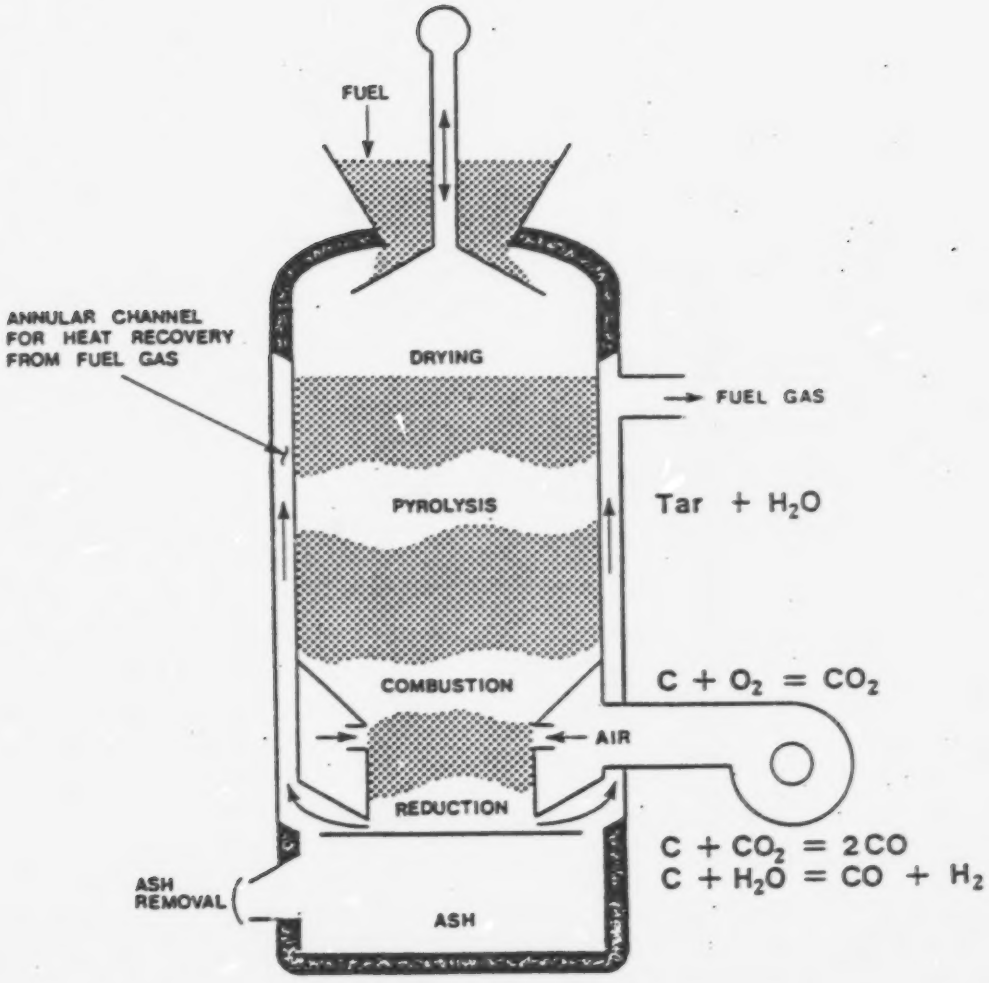


FIGURE 5-3: DOWNDRAFT GASIFIER

SOURCE: ENFOR Project C-258

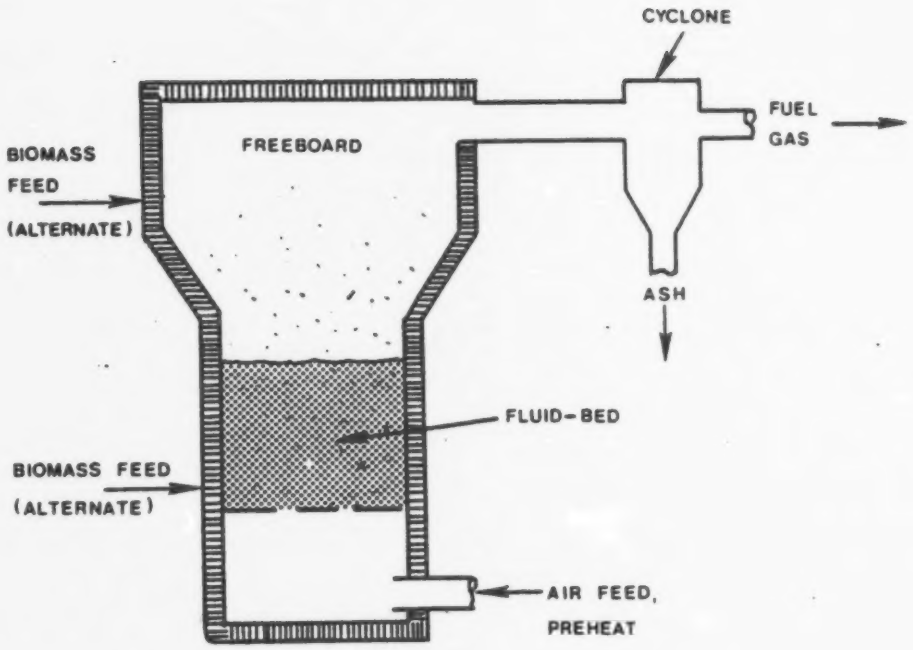


FIGURE 5-4: FLUID-BED GASIFIER

SOURCE: ENFOR Project C-185

output was 4.22 GJ/hr. of low heating value wood gas (i.e. 5 MJ/m^3).

The unit failed to achieve a 15 day continuous run. The failure was attributed to many factors including the inappropriateness of the plant and mechanical breakdown. In the failure analysis of the test run, 45% of the shutdowns were attributed to severe smoke leakage, 25% to centrifugal tar extractor problems, 15% to overheating and the balance to planned shutdowns at the end of the working day. Problems were identified that were associated with feeding into a positive pressure system and the inability to fluidize the fuel. Saskatchewan Power concluded that fluidized and fixed bed gasifiers were feasible and that the technology could become a viable alternative to diesel systems, if wood could be purchased for no more than $8.00 per oven dried tonne,

From 1981 to the present, Snowshoe Inn Limited in Fort Providence, N.W.T., has operated a 120 KW Imbert downdraft gasifier. At the time of the final report in March of 1984, the plant had been in operation intermittently for 18 months. A total of 562 cords of jackpine had been pyrolized to produce wood gas. As with the Hudson Bay gasifier, mechanical and equipment difficulties arose. Two major operational problems surfaced. One problem was unwanted air entering the gasifier during each feeding cycle. This inrushing air would result in

engine stalls. The other major problem was the feed system bridging in the air-lock and day hopper.

Of perhaps significant consideration is that the Imbert gasifier had less problems than the B.C. Research fluid bed gasifier with tar buildup. This phenomena is reflected in Tables 5-5 and 5-6. Downdraft gasifiers produce a gas with the least amounts of condensible tars, oils and particulates. Levelton, in ENFOR Projects C-185 and C-258 prefers the use of downdraft gasifiers if the process is to maximize wood gas for use in a system which produces electricity.

An examination of Figure 5-3 illustrates why fuel gas produced in a downdraft gasifier is cleaner than gas produced from other designs. First, fuel is fed from the top, dried, pyrolized, then combusted. Air is introduced in the reduction zone. Fuel gas exits the gasifier after reduction takes place. Some designs pass the fuel gas over the outside sections of the reactor containing the pyrolysis and drying zones to improve thermal efficiency. Since the fuel gas passes through a porous hot bed of char in the reduction zone, it contains less than 10% of the condensible hydrocarbons produced from an updraft gasifier. The fuel gas exits at a high temperature and with a low enough velocity to let most of the ash that is produced in the combustion and reduction zone to settle out.

TABLE 5-6: TYPICAL PERFORMANCE CHARACTERISTICS OF DOWNDRAFT GASIFIERS

Combustible Gas Ouput (GJ/h)		0.1 - 10.0	
Fuel Feed Rate (oDt/h)		0.007 - 0.7	
Grate Energy Release Rate (GJ/hm^2)		1.5 - 4	
Energy Balance: 100% fuel input yields:		75% cold, clean gas 15% sensible heat of gas —% tars and oils 10% heat losses	
Inputs:	Fuel size (mm)	25 - 150	
	Moisture content (%, wb)	<30	
	Air/fuel ratio (kg/kg)	1.3 - 1.7	
	Operating power (kWh/GJ)	3 - 6	
Outputs:	Gas exit temperature (°C)	350 - 600	
	Gas Composition (Vol %)	As Produced	Dry and Cold
	N_2	44.1	47.4
	CO_2	11.7	12.6
	CO	18.9	20.3
	H_2	15.3	16.5
	CH_4	1.9	2
	C_2^+	1.1	1.2
	H_2O	7	—
	oils and tars	—	—
Higher Heating Value (MJ/m^3)		4.7 - 5.6	5.0 - 6.0
Lower Heating Value (MJ/m^3)		4.3 - 5.2	4.6 - 5.5
Condensible Yield:	H_2O (kg/kg wet feed)		0.01 - 0.24
	Oils and tars (kg/kg dry feed)		very low
Ash and Char Yield (kg/kg dry feed)			0.01 - 0.02
Particulate at 101 kPa, 20°C Before Cleanup (g/m^3)			N/A

SOURCE: ENFOR Project C-258

Although Levelton in Table 5-5 states the status of downdraft gasifiers as being commercial, the operator of the Snowshoe Inn gasifier in Fort Providence concluded in his final report the following two items:

(1) wood gasification at this time for electrical power generation has not yet reached the desired level of reliability;

(2) it appears that with the biomass feed problems associated with this gasifier, continuous supervision would be necessary each hour the plant is in operation.

Although the use of gasification technologies look attractive for generating electricity in remote communities, it appears the stage of technological reliability required has not been achieved. Further demonstrations and test trials are required before this technology can be widely implemented. Further research should perhaps focus on the problems of excess combustion air and automated feed systems.

For comparative purposes, Table 5-7 contains a summary for the installed costs of a 250 KW downdraft gasifier. Note the absence of a chipper system.

TABLE 5-7: SUMMARY OF INSTALLED COSTS OF A 250 KW DOWNDRAFT GASIFIER

COST ITEM	COST ($1,000)
Direct Costs	
Pit and Chain Reclaimer	96.0
Belt Conveyors (2)	42.5
Fuel Storage Bin	38.0
Gasifier (including gas cleanup)	180.0
Engine-Generator	224.0
Building	14.4
TOTAL DIRECT COST	594.9
Indirect Costs	
Engineering (6%)	35.7
TOTAL COST	630.6

Source: ENFOR: Project C-258

5.4 EXAMINATION OF THE STEAM GENERATION SYSTEM

5.4.1 Steam Generation Equipment

As per ENFOR PROJECT C-258 "Data Book of Unit Processes for Primary Conversion by Direct Combustion"; there are eleven companies that produce stoker furnaces for steam generation. During our research, we found two other manufacturers that were not listed in the study. Assuming an overall efficiency of 20% to produce 150 KW we will need a boiler capacity of 750 KW or 75 Bhp.

The following list of manufacturers and their equipment were examined:

1. B.E.S. Energy Equipment Ltd.
2. Babcock and Wilcox Canada Ltd.
3. General Iron Works Ltd.
4. Hurst Boiler and Welding Co. Inc.
5. Johnston Boiler Inc.
6. Mottpac Boiler Inc.
7. Ray Burner Co.
8. Volcano Inc.
9. Weiss Mini-boiler Systems
10. Wellons Inc.
11. York-Shipley Inc.
12. Vertec Combustion Systems
13. Saskatoon Boilers

Many were eliminated on the basis that they do not produce equipment small enough for the capacity under consideration. Some of the eliminated manufacturers showed real interest in this project and are willing to have their engineers examine the possibility of designing smaller boilers if they see a market developing.

The following manufacturers can provide the required equipment and have submitted information and prices: (Refer to Table 5-8).

1. Johnston Boiler Company Inc.
2. Ray Burner Co.
3. Weiss Mini-Boiler Systems

Of the above the most promising equipment are the Weiss Mini-boiler Systems and the Johnston Boiler Company Inc. The manufacturers are selected on the basis of having the most installations (Weiss) and Canadian experience (Johnston-Boiler Company Inc. Vancouver, B.C.) - (Refer to Table 5-8).

5.4.2 Boiler Selection

The Boilers Act certificate requirement is based on boiler size rather than boiler operating pressure.

The advantage of a system that utilizes a higher boiler pressure and temperature is that the overall thermodynamic efficiency of the system would be higher.

This is the reason why a diesel engine has a higher efficiency than a gas engine. Based on the above it seemed advantageous to select a boiler that can produce the highest possible pressure. A secondary advantage is that the higher pressure would require a smaller size turbine to generate the electricity.

There are two types of boilers: the firetube boiler and the watertube boiler. The firetube boiler normally

TABLE 5-8: BOILER CHARACTERISTICS

BOILER	BOILER TYPE & SIZE		MAX. MOISTURE CONTENT	BOILER EFF.	FUEL TYPE	TURNDOWN RATIO	POLLUTION CONT. DUST COLLECTOR	COST
Weiss	Firetube	100 bhp derated	up 45% can be upgraded to 55%	68-70%	Hog fuel, chips sawdust & densified pellets	Not Stated	Mechanical Dust Coll.	$68,850 U.S.
Mottpac Boilers Inc.	Firetube		55%		Hog fuel, chips sawdust & densified pellets	3 to 1	Primary Cyclone Dust Coll.	Could not be reached
Ray Bainer	Firetube	100 bhp	20% Max.	not st.	Wood, chips OK Sawdust shavings densified pellets	2/3 to 1	Dust Coll.	$150,000 U.S. Moisture Content to crit
Johnston Boiler Co.				60-70%				
Johnston Boiler Co.								
Vertec								$100,000 CAN No prev. Install-ations.

Unfortunately for the required boiler size mostly firetube boilers are manufactured; (we came across a single manufacturer that was prepared to custom build a watertube boiler). An important consideration in selecting this lower pressure boiler was that water treatment would not have to be elaborate. This we felt was especially important in a remote community. For larger systems most boiler equipment are watertube type.

We selected a firetube boiler that would operate at 225 psi with a 15 - 20°F superheat.

5.4.3 Turbine & Generator Selection

Turbine and generator selection was closely tied to the boiler selection as it is entirely dependent on inlet pressure and temperature conditions.

To protect the turbine, inlet conditions require good quality steam. To achieve good steam quality, the manufacturer suggested superheating the steam 15 - 20°F in order to remove all moisture from the steam supply.

Alternatively, a good quality moisture seperator should be used prior to feeding the turbine.

Budget equipment cost for the turbine/generator assembly for the 150 KW generator system (480 Volts, 3-phase) was quoted as $50,000.00 CANADIAN. If a separator was to be used, the cost will be approximately $5,000 extra.

operates up to 300 psi while the watertube can operate up to 900 psi.

In the firetube boiler design, steam puts stresses on the outside of the boiler shell and the shell has to be designed to take the pressure. In practice, it would be excessively expensive to construct the shell to take pressures higher than 300 psi.

In the watertube boiler, the water or (steam in this case) is inside the tube and the heating medium is outside the tube. So the outside shell of this boiler does not have to take the high pressure. Technically, the pipes or tubes can take the 900 psi pressure without a problem. Many pipes especially in the oilfield industry can take thousands of pounds pressure without a problem.

From a system responsiveness point of view, the watertube boiler can generate steam faster than a firetube boiler.

The original intention was to select a watertube boiler that would operate at 600 - 700 psi. A steam system operating at that pressure was observed in Inuvik. The impressive part of that system was that the steam produced (by burning fossil fuel) was used to heat a large portion of the town. The size of steam pipe used to heat a 10,000 square foot building was only 3/4" ϕ.

Turbine inlet condition for the above system were 225 psi and 20°F superheat. Turbine outlet pressure were 50 psi and saturated steam.

It should be noted that a large turbine/generator assembly delivering 250 KW would cost $63,312 CANADIAN.

The disadvantage of high speed rotating equipment is that specialized parts are not readily available and would have to be flown in.

5.4.4 Steam Engine & Generator Selection

The steam engine was looked at as an alternate to the turbine due to the fact that some firetube boilers are not capable of providing superheated steam. Steam engines are less sensitive to moisture content and are more tolerant of chemical contamination in boilers. Steam engine manufacturers did point out that their steam generator set can be run with a 20% overload for up to two hours.

On the negative side, the initial steam engine generator package cost was $64,594 U.S. which is higher than the turbine. The above includes the engine, gearbox, generator coupling, guards, base plate, inlet separator, exhaust separator and inlet shut-off valve. Quoted system efficiency was 44.5%.

It is interesting to note that the steam engine manufacturer that we talked to in the United States is having a resurgence of business activity as a lot of people are calling

in for biomass system inquiries. Many applications are for third world countries. The big attraction is that third world countries have shortage of funds to buy the diesel fuel in the international market. On the other hand, they have inexpensive labour available along with some form of waste material that can be used for biomass.

The above combination along with the need for electricity is making biomass systems attractive as the need of the country is met with a diminished export of capital to the oil producing countries. It is also of interest to note that in these countries, the biomass is fed manually and the average electrical system range is from 10-112 KW!

5.4.5 Heat Rejection

Three alternative heat rejection systems were evaluated to determine the initial cost, the power requirements, and the maintenance cost. The heat rejection system would be required whether or not the waste heat can be effectively used during winter in a co-generation application.

5.4.5.1 Heat Rejection to a Lake, Stream Or River

According to the Alberta Environment, the maximum acceptable temperature difference between lake temperature and return water temperature is $3^{0}C$. The system configuration would be as follows;

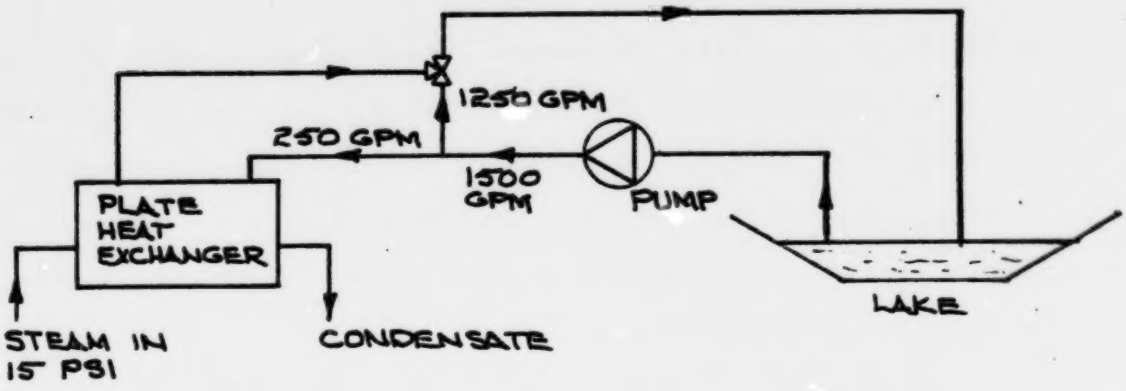


FIGURE 5-5: HEAT REJECTION TO BODY OF WATER

This system is used extensively in the larger installations (Wabamun Lake). System cost is site specific. Similarly pump power requirements are directly dependent on flow rate and pump head.

Cost estimates on the Trout Lake and Garden Creek vary as follows:

<u>Fixed Equipment Costs:</u>

Pump	$ 10,000.00
Pump (standby):	$ 10,000.00
Heat exchanger	$ 3,323.00
Piping 500' Asbestsos Cement	$ 5,000.00
Pumphouse	$ 7,500.00
Excavation and backfill (250')	$ 5,625.00
Mobilization	$ 5,000.00
Possible dewatering	$ 2,000.00
TOTAL:	$ 53,448.00+

Annual maintenance cost	High
Power Requirement	50 HP

NOTE: There are more costs in selecting this alternative as this solution is highly site specific with real problems to contend. In Trout Lake, for example, the Creek is not a dependable water source (it dried up temporarily last year). Installing piping to the lake and protecting it from freezing involves dredging which is very expensive. In Garden River, a similar problem exists with the steep banks of the mighty Peace River.

5.4.5.2 Heat Rejection Using Fluid Cooler

The heat with the above system is rejected to the air. System configuration is as follows:

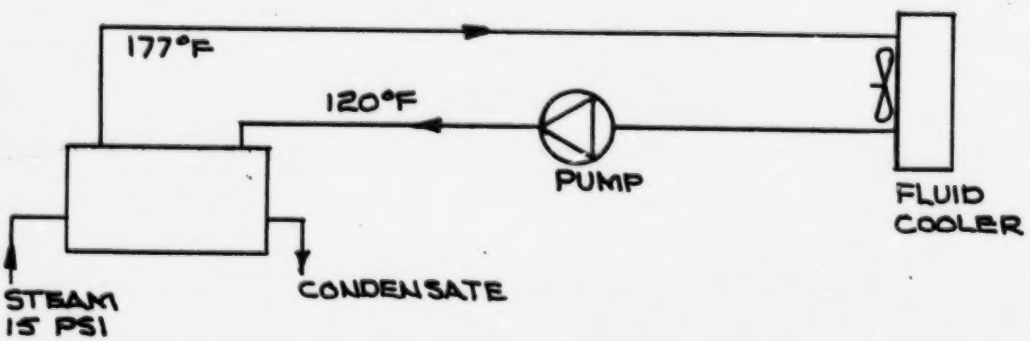


FIGURE 5-6: HEAT REJECTION USING FLUID COOLER

The advantage of the above system is that it is site independent. The heat is rejected to the atmosphere without any of the usual problems associated with lake, i.e. high algae growth and unsafe ice conditions due to thermal currents in the lake.

In addition, it should be easier to install without the possibility of pipe freeze-up or ice movement against the pipe.

Cost of the above arrangement is as follows:

Fluid cooler	$ 20,000.00
Heat exchanger	$ 2,770.00
Pump	$ 1,329 + Federal Tax
Pump (stand-by)	$ 1,329 + Federal Tax
Piping Cost (incl. labor)	$ 4,000.00
Electrical (incl. labor)	$ 3,000.00
Controls (incl. labor)	$ 3,000.00
TOTAL:	$ 35,428.00

Annual maintenance cost	Low
Power consumption	20 HP Fluid Cooler + 7 1/2 pump

The cooling tower alternative was eliminated due to the higher equipment and maintenance cost in addition to the wasted water.

5.4.5.3 Heat Rejection Using Air

The third system utilizes an air handling unit with a heating coil in it rather than a fluid cooler. The advantage of this arrangement is that it could be used to air dry the biomass.

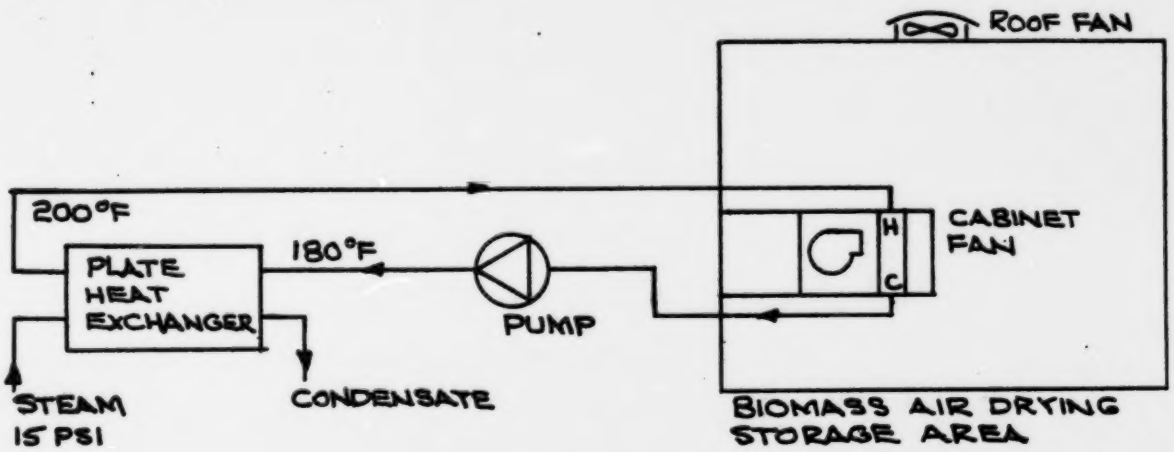


FIGURE 5-7: HEAT REJECTION USING AIR

Approximate cost of the above alternative:

Air handling unit (40,000 cfm) @ $1.00/CFM	$ 40,000.00	
40' of 55' ϕ diameter duit	$ 3,520.00	
22 lbs/ft x 40' = 880lb @$4/lb mobilization +extra trade	$ 5,000.00	
Roof exhaust fans, for summer	$ 6,000.00	
Plate heat exchanger	$ 2,770.00	
Pump	$ 1,329.00	+ Federal Tax
Pump (stand-by)	$ 1,329.00	+ Federal Tax
Electrical	$ 5,000.00	
Controls	$ 4,000.00	
TOTAL:	$ 68,948.00	

Power Requirement:

Roof exhaust fan	10 hp
Pump	7 1/2 hp
Air handling unit	30 hp

With this alternative, it looks possible to go directly from the 15 psi steam directly to a steam coil in the air handling. However, there are other considerations i.e. possibility of freezing steam coil and design pressure of the steam coil.

5.5 SYSTEM POWER MODEL

System power requirements vary according to the degree of automation, the type of fuel required and the type of heat rejection system selected. In this study we started by looking at fuel preparation energy requirements and the energy requirements of an automatically fed steam boiler system. Feed rate varies automatically according to the power demand of the electrical distribution system.

Typical system model for a generating system producing 150 KW is as follows:

5.5.1 Fuel Preparation Electrical Energy Requirements

In the fuel preparation, the log splitter can be operated separately and the split logs accumulated near the chipper. Subsequently the logs can be chipped, screened and conveyed to the storage bin. The time and energy requirement of the process is discussed in section 5.5 and 5.6.

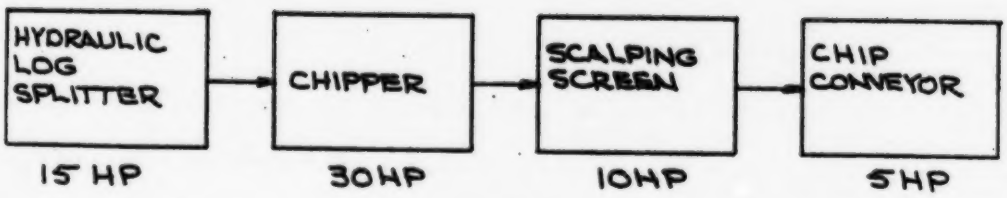


FIGURE 5-8: FUEL PREPARATION ELECTRICAL ENERGY REQUIREMENTS

5.5.2 Plant Energy Model

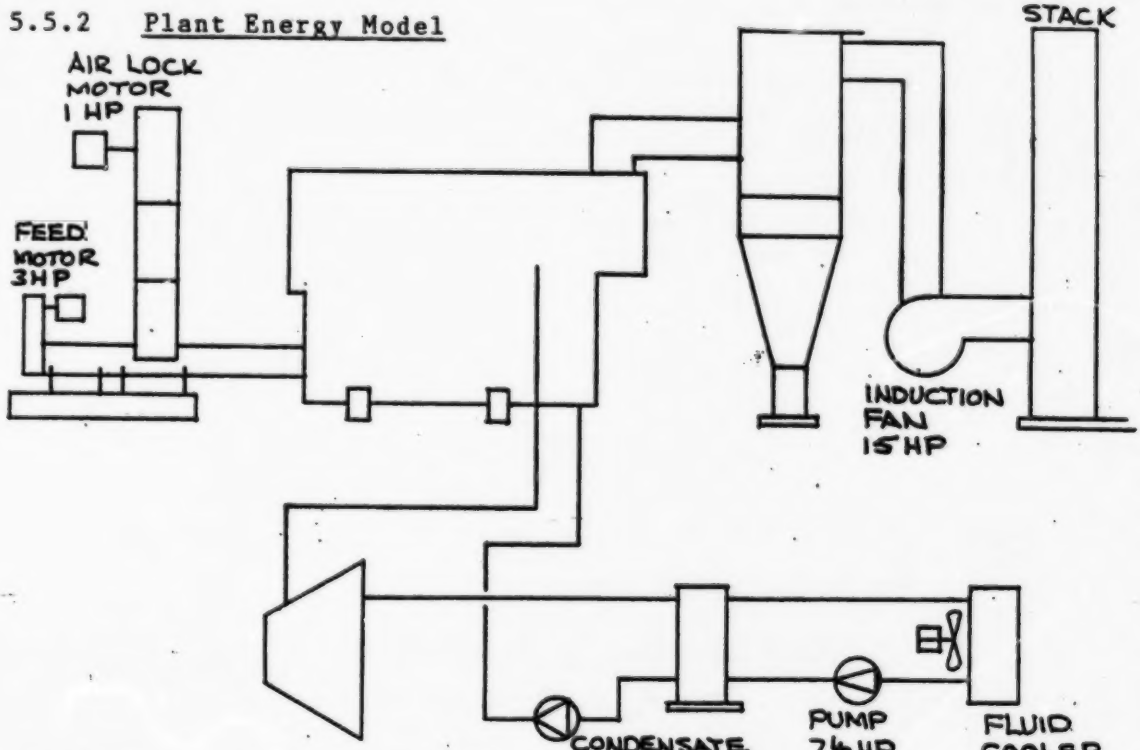


FIGURE 5-9: PLANT ENERGY MODEL

Plant electrical requirements: 47.5 Hp or 36 KW

Portion of electrical energy run the plant = $\frac{36}{150}$ = 24%

Total available power available for the community = 114 KW

5.6 PLANT EFFICIENCY

Plant efficiency is calculated by multiplying the sum total of all individual efficiencies. For the automatic feed system under examination, the following efficiencies were submitted by the different equipment manufacturers:

Boiler	60 - 68% (using wood chips)
Steam Engine	44.5%
Turbine	48% - 65% (depending on inlet and outlet conditions)

Boiler feed and exhaust system:

Calculated as follows:

15 hp (induction fan) + 3 hp (automatic feed) + 1 hp (air lock) = 18 hp or 13.6 KW with a usage factor of 70%

System Efficiency:

$$= \frac{\text{Total Energy Produced-Energy used for feed}}{\text{(Total energy produced)}} \times 100\%$$

$$= \frac{150\text{KW} - (13.6\ \text{KW} \times 70\%)}{150\text{KW}} \times 100\% = 93.6\%$$

Heat rejection system (fluid cooler): 20hp or 15.12 KW

Efficiency component:

$$= \frac{\text{Total Energy Produced-Energy Used for Fluid Cooler}}{\text{Total Energy Produced}} \times 100\%$$

$$= \frac{150\text{KW}-15.12\text{KW}}{150\text{KW}} \times 100\% = 89.9\%$$

and Pumping system motor size: 7.5 hp or 5.67 KW

however actual draw from pump curve = 5 hp or 3.8 KW

$$\text{Efficiency component} = \frac{150\ \text{KW} - 3.8\ \text{KW}}{150\ \text{KW}} \times 100 = 97.5\%$$

Total efficiency of biomass steam engine plant

= .60 x .445 x .936 x.90 x .975

= .219 or 21.9%

Total efficiency of biomass steam turbine plant

= .60 x .56 x .936 x .90 x .975

= .275 or 27.5%

It should be noted that the above efficiencies do not take into account the energy required to prepare the fuel and probably fuel shrinkage.

Overall efficiency of biomass steam engine plant

= .219 x fuel preparation factor x shrinkage factor

= .219 x .89 x .85 = .165 or 16.5%

Similarly:

Overall efficiency of biomass steam turbine plant

= .275 x .89 x .85 = .208 or 20.8%

5.7 FUEL PREPARATION ENERGY ESTIMATE

The chipper under consideration requires the following equipment to run as a group to chip and transport the wood.

Chipper	30 hp
	5 hp
Conveyor	10 hp
	45 hp or 34 KW.

The chipper under consideration can chip at the rate of 2,000 lbs./hr. If yearly wood requirement is 500 cords of wood (first year), then the amount of wood to be

$$\text{chipped/week} = \frac{500 \text{ cords}}{52 \text{ weeks}} = 9.6 \frac{\text{cords}}{\text{week}}$$

and the time required to chip a week's supply is:

$$\text{Time} = \frac{\text{Amount of wood to be chipped}}{\text{Feed rate}} =$$

$$= 9.6 \frac{\text{cords}}{\text{week}} \times 1.34 \frac{\text{TONS}}{\text{cord}} \times 2000 \frac{\text{lbs}}{\text{TON}} \times$$

$$\times \frac{1}{2{,}000 \text{ lbs/hr}}$$

$$\text{Time} = 12.8 \frac{\text{hrs}}{\text{week}}$$

The above time of 12.8 hrs/week might be rather low as the chipper might not be utilized to its full potential since it is fed manually and 20 hrs/week might be a more accurate number.

The yearly energy requirement to chip the wood would be =

$$= \frac{20 \text{ hrs}}{\text{week}} \times \frac{52 \text{ weeks}}{\text{year}} \times 34 \text{ KW} \times 1 \text{ year} = 35{,}360 \text{ KW-hrs}$$

Similarly the energy required to split 9.6 cords of wood/week, using a 15 hp (11.34 KW) wood splitter and assuming that it requires 3 hours per week to split wood that is greater than 6" diameter was calculated as follows:

$$\text{Energy Requirement}_{\text{Wood Splitting}} = \frac{3 \text{ hrs}}{\text{week}} \times \frac{52 \text{ weeks}}{\text{year}} \times 11.34 \text{ KW} \times 1 \text{ year}$$

$$= 1{,}769 \text{ KW-hrs}$$

Therefore total yearly energy requirement to prepare 500 cords of fuel is 35,360 KW-hrs + 1,769 kW-hrs = 37,129 KW-hrs.

Cords of wood required to produce the above electricity

$$= \frac{37,129 \text{ kW-hrs}}{700 \text{ KW-hrs/cord}} = 53 \text{ cords of wood}$$

the fuel preparation efficiency factor is

$$\frac{500-53}{500} = 8.9 \text{ or } 89\%$$

It should also be expected that some wood shrinkage might occur from the yard.

If this loss is kept to 15%, then the total available for biomass would be 85%.

5.8 TRANSPORTATION OF FUEL - GARDEN RIVER

Garden River is located within the National Park. This site was selected because it is close to all the logging operations by CANFOR. The intent was to see if it would be possible to utilize the trimmings, or the tree tops from the operation or alternatively to use the existing nearby poplar and/or aspen.

We wrote to the department of Parks Canada and they would not allow any harvesting at this time. There is talk, however, that the entire Garden River Community might be removed from the Park.

In getting the free biomass for the lumber operation we noted that the lumber tenure would end in the year 2,001. The

lumber company is only allowed to cut overmature stands. It is estimated that their operations would be complete in 10 to 11 years at the present schedule depending on market conditions.

Presently logging trucks pick up their load from inside the Park, pass near Garden River located near the entrance, and deliver the logs at the processing plant in High Level. The logging trucks return from High Level to Garden Creek empty. Unfortunately, because of the design of a logging truck (no structural strength in the middle) it would not be possible to ship back the biomass unless these trucks were modified to carry containers and it is highly doubtful that the lumber company would allow modification of their logging trucks as it might hamper their operation. On the positive side there is more waste biomass from the logging operation in Garden River than is needed for electricity production.

Shavings, sawdust and bark require 2 1/2 times more volume than logs. If another truck were to transport the biomass from High Level, the approximate volume of biomass that it can carry was calculated as follows: Assuming box dimension is 6' wide by 7' high and 30' long then its volume would be 6' x 7' x 30' = 1,260 ft^3 and 1 cord of wood in shavings and sawdusts would take up 2.5 x $(\frac{128 ft^3}{cord})$ = $\frac{320\ ft^3}{cord}$. Each trip would result in the transportation of 1,260 ft^3/cord = 4 cords of wood. If the first year biomass requirement is 500 cords that translates into 500 ÷ 4 = 125 trips due to the distance

involved, this solution would not be economically feasible. The other problem to consider is that since the biomass is to be stored for a year's supply (all logging is done in winter for both Trout Lake and Garden Creek) the required yard area would be 2.5 times the size. Another consideration is that some form of biomass (wood chips) is subject to spontaneous combustion and poses a fire hazard.

5.9 Transportation of Fuel - Trout Lake

The closest sawmill operation to Trout Lake is located in Red Earth, approximate distance being 60 miles on gravel road. Estimated travel speed on this road is 40 miles/hr. average in good weather. Quotes received on transportation of wood chips and shavings range from $1.20/mile to $250/trip.

Using the information derived from section 5.8 (i.e. 125 trips to transport 500 cords) the annual transportation cost would be approximately 125 trips x $250.00 = $31,250. or cost/cord = $\frac{\$31,150}{500 \text{ cords}}$ = $62.5/cord.

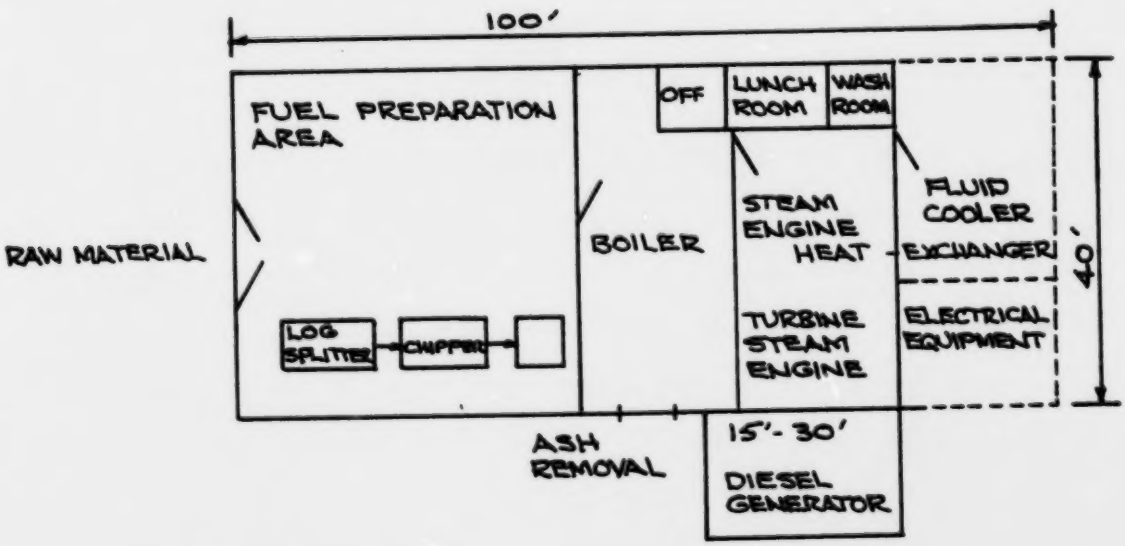
Using the $1.20/mile figure the transportation would cost 120 miles/round trip x 125 trips x $\frac{\$1.20}{\text{mile}}$ = 15,000 miles x $1.20/mile = $18,000. On the cost/cord = $\frac{\$18,000}{500 \text{ cords}}$ = $36.00/cord. The above cost runs very close to the harvesting cost assuming the sawmill does not receive renumeration for their sawdust and shavings.

5.10 TYPICAL PLANT LAYOUT

Due to the high initial biomass equipment cost when compared to that of a deisel generating plant, it is proposed to design the biomass system according to present peak requirements. The intent is to use the biomass system in the future as base load and using a small deisel generating plant to shave the peak. A second diesel generating plant would also be incorporated in the design as full back up should a failure occur.

Preliminary biomass plant selection is based on 150 KW. The above plant would have 116 KW available (excluding the demand of the fuel preparation equipment 34 KW lasting 2.5 to 3.0 hours daily).

Preliminary Plant Layout of Pre-Engineered Building



5.11 PLANT LOCATION

In selecting a site for the plant with the fluid cooler arrangement location is no longer critical. Just the same the plant should be located with the following criteria in mind:

1. Close to the road.
2. Close to a source of good water (well water is detrimental to the boiler)
3. Close to the electrical grid.
   Note: the plant does not have to be at the source location as existing deisel generation plant.
4. Away from the residences.
5. Close to the large users of energy if co-generation is promising (school, laundromat, etc.)
6. Yard size - 2 hectares.
7. Relatively high flat ground with good drainage.

In Trout Lake a possible location would be close to the existing refuse dump. This location is rather far from the school for co-generation puroses. In Garden Creek a possible location would be near the existing deisel generating station and close to the new school and laundromat.

6.0 ECONOMIC ANALYSES

For the purposes of performing comparative analyses, the economics of diesel generating systems are examined against a variety of biomass conversion technologies. In particular, the use of biomass conversion systems utilizing steam engines or turbines are examined for varying fuel preparation systems and biomass costs. Having defined how technologies affect the project's feasibility, the next and final analysis involves a benefit-cost tabulation for a site specific project in Trout Lake.

The economic analyses are performed by conducting present value costs of capital and operating charges. For calculations involving periodic annual capital outlays, present values are calculated from the following formula.

$$PV = So \frac{(x^{n+1}-1)}{(x - 1)}$$

This formula is derived from the geometric series of present values. The variable x is simply the ratio of (1 + i), i being the rate at which the specific material cost (fuel, labor etc.) is escalating divided by (1 + r), r being the discount rate. The factor n is the number of years the series is being projected over.

An example of how this formula is used is the present value calculation of diesel fuel costs. In the 1984 NEP update, real annual growth rates for the price of crude oil are

given as being 3% (high case), 1.5% (reference) and 0% (low case). Assuming a constant discount/interest rate of 12%, and inflation remaining constant at 5% for the next 20 years the variable x becomes the following:

(1) High case: $x = \frac{1.08}{1.12}$, PV = So (15.0)

(2) Reference: $x = \frac{1.065}{1.12}$, PV = So (13.3)

(3) Low case: $x = \frac{1.05}{1.12}$, PV = So (11.90)

The symbol So is the current value of annual diesel fuel costs.

6.1 PRESENT VALUE OF DIESEL GENERATING SYSTEMS (1985-2005)

6.1.1 Capital Costs:

	Present Value (in 1,000's of dollars - 1984)
- complete installation of two 150 KW generating systems with fuel storage facilities and building	150

6.1.2 Operating Costs:

(a) Fuel:

- over 20 years, 20% conversion efficiency
- average annual power production of 700 MWH
- average annual fuel required: 323,000 litres
- current price: $.37/litre
- discounted at 12%
- present annual fuel cost (So): $120,000
- present value:

i) High (So x 15.0)	1800
ii) Reference (So x 13.3)	1600
iii) Low (So x 13.7)	1430

(b) Maintenance Calculation:

- acccording to diesel manufacturers plants are overhauled according to the following hours (costs are calculated as a percentage of diesel plant and generator valued at $40,000):

  i) first 5000 hrs - 5%
  ii) at 10,000 hrs - 10%
  iii) at 15,000 hrs - 5%
  iv) at 20,000 hrs - 45%
  (i.e.: major overhaul)

- the maintenance cycle repeats itself after major overhauls.
- as the major costs occurs every 20,000 hrs., the costs calculated below are deemed to occur every 2.3 years.
- included in this cost is the additional 20% from earlier minor overhauls.
- therefore the costs occur eight times during the projection period of 20 years.
- for each major overhaul, 65% of generator and diesel plant costs are used; these costs increase in price 5% per year and are discounted at 1 %.
- fly in and lodging costs for overhaul crew included? (ie: minor)
- plants have been known to operate for 20 years using this maintenance program.
- present value 113

(c) manpower (general supervision)

- local overseer, $3,000 annually
- utility staff, monthly visits to inspect plant $6,000 annually

- costs increase at 5%, discounted at 12%	
- presentvalue	107
TOTAL PRESENT VALUE (REFERENCE) for diesel generating system	$ 1,970,000

Given that it is expected that 700 MWH x 20 years = 14 x 10^{10} KWH of energy will be produced, the cost of producing one KWH equals: $\frac{1,970,000}{14 \times 10^{6}}$ = $ .14/KWH

This cost is well above the current rate charged to consumers in urban areas and in remote communities.

Another way to examine the costs of operating a diesel generating system for 20 years is to see by percentage where the costs are incurred.

(a)	manpower	5%
(b)	capital costs	8%
(c)	maintenance	6%
(d)	fuel costs	81%

This analysis shows that overall costs are largely attributed to fuel expenditures. Using the high case forecasts by the NEB FUEL COSTS WOULD ACCOUNT FOR 83% of the present value of $2,170.00.

6.2 PRESENT VALUE OF BIOMASS CONVERSION SYSTEMS (1985-2005)

In each one of the following scenarios, two options are examined for the secondary conversion unit process-steam engines and steam turbines. In the first scenario, the fuel preparation and handling process is varied keeping other

factors constant, in the second scenario, the cost of biomass is varied keeping other factors constant.

6.2.1 Chipper With Automated Feed System

In this scenario, a chipper is used along with an automated feed system. The incorporation of a chipper reduces the net conversion efficiency by 15%. Present value calculations assume material/labor price rate escalation of 5% discounted at 12%.

6.2.1.1 Equipment Costs

Unit Process	Cost (in 1000's)	Life Expectancy years	Present Value (in 1000's of dollars)
1. Fuel preparation & handling:			
- tractor	30	20 yrs.	30
- log splitter	10	10 yrs.	15
- chipper in feed conveyor	6	10 yrs.	9
- V drum chipper	40	10 yrs.	61
- chip outfeed conveyor	8	10 yrs.	12
- fuel bin	10	30 yrs.	10
- grinder, jigs	6	20 yrs.	6
TOTAL:	110		143
2. Primary Conversion:			
- boiler (69,000 US) includes bare boiler, fly ash collectors, induced draft fan and screw metering device	90	25 yrs.	90

Unit Process	Cost (in 1000's)	Life Expectancy years	Present Value (in 1000's of dollars)
- dual relief valves and boiler trim (4,000 US)	5	25 yrs.	5
- controls for modulating steam and feed (12,500 US)	16	25 yrs.	16
- water treatment system	25	25 yrs.	25
TOTAL:	136		136
3. Pollution Control - Heat Rejection:			
- fluid cooler	20	20 yrs.	20
- heat exchanger	3	20 yrs.	3
- pumps (two)	3	20 yrs.	3
- piping	4	40 yrs.	4
- electrical	3	25 yrs.	3
- controls	3	25 yrs.	3
TOTAL:	36		36
4. Secondary Conversion:			
Option #1 - Steam Engine - includes steam engine, gearbox, generator and generator coupling, guards, base plate, inlet and outlet separators, inlet shut-off valve ($65,000 US)	85	30 yrs.+	85
Option #2 - Steam Turbine - comes as entire package	50	25 yrs.+	50

Unit Process	Cost (in 1000's)	Life Expectancy years	Present Value (in 1000's of dollars)
5. Peripheral Equipment			
- piping - high pressure	4	40 yrs.	4
- pipe insulation	1	40 yrs.	1
- valving	3	20 yrs.	2
- water pipe feed	2	20 yrs.	2
TOTAL:	10		10

TOTAL PRESENT VALUE OF EQUIPMENT COSTS:

Option #1 (Steam Engine): $410,000
Option #2 (Steam Turbine): $375,000

6.2.1.2 Other Capital Costs

	OPTION #1 (Steam Engine) $1000's	OPTION #2 (Steam Turbine) ($1,000's)
1. freight and insurance (10% of equipment	41	38
2. Contractor costs, i.e. assembly, supervision, planning and equipment profit (30% of equipment)	123	113
3. Consultants costs, i.e. design & site supervision (12% of equipment)	49	45
4. Contingency costs (15% of equipment)	62	56
5. Building cost (i.e. 4,500 sq.ft. x $30/sq.ft. plus 15% contingency)	155	155
TOTAL:	$430,000	$407,000

TOTAL PRESENT VALUE OF OTHER CAPITAL COSTS:
Option #1: $430,000
Option #2: $407,000

6.2.1.3 Operating Costs

	Annual ($1,000's)	Present Value ($1,000's)
A. Maintenance		
Fuel Preparation & Handling - maintenance (50% of equipment costs)	21	250
Balance of System - maintenance (2.5% of equipment-equal for either option	10	119
TOTAL:	31	369
B. Labor		
- assumes plant operates 24 hours per day, year round		
- Chief engineer (S 36,000 per annum)	36	428
- one boiler attendant per shift, i.e. 4.2 man years at rate of $20,000 per man year	84	1000
- one yard man ($20,000 per annum)	20	238
TOTAL:	140	1666
C. Biomass		
- as from section 5.2, 625 cords needed on the average each year	31	369
- price: $50.00 per cord		
TOTAL OPERATING PRESENT VALUE:	$2,404,000	

6.2.1.4 Present Value Summary

The entire present value of a biomass conversion system is shown in Table 6-1 below:

TABLE 6-1: PRESENT VALUE OF BIOMASS SYSTEM WITH CHIPPER AND AUTOMATED FEED SYSTEM

Item	Present Value ($1,000's of dollars)	
	Steam Engine	Steam Turbine
Equipment Costs	410	375
Other Capital Costs	430	407
Operating Costs	2,404	2,404
TOTAL:	3,244	3,186

Figure 6-1 examines these present values in both absolute and percentage terms in order to view where the expenses are deriving from. An average cost of the secondary conversion units are used (i.e. $68,000) as with other Capital Costs ($419,000).

FIGURE 6-1: EXPENSE ANALYSIS OF THE CONVERSION SYSTEM INCORPORATING A CHIPPER AND AUTOMATED FEED SYSTEM

Fuel Preparation & Handling (19%)

- equipment: $143,000 (4%)
- maintenance: $250,000 (8%)
- labor: $238,000 (7%)

Labour:
$1,666,000 (52%)

Maintenance
$369,000 (11%)

Primary & Secondary Conversion Units (56%)
(i.e. balance of Conversion System)

- equipment: $250,000 (8%)
- maintenance: $119,000 (4%)
- labour: $1,428,000 (44%)

Equipment:
$393,000 (12%)

Other Capital Costs:

$419,000 (13%)

Biomass:

$369,000 (11%)

T O T A L: $3,216,000

An examination between diesel and biomass generating systems illustrates dramatic differences as to where expenses occur: In the diesel system, approximately 80% of the expenditures are for acquisition of fuel versus 11% for biomass. The largest expenditure in the biomass conversion system is for labor, i.e. 52% of all costs. If one considers that the capital which purchases biomass is retained in the community, then approximately 63% of the capital necessary to operate the plant is left in the community. In absolute terms, the percentage equates to $2,025,000. This figure is in the same order of magnitude as the entire present value for the diesel generating system ($1,970,000).

6.2.2 Free Biomass - No Chipping Required

The analysis in figure 6-1 illustrates that the front end of the conversion system, fuel preparation and handling, involves somewhat a disproportionate amount of the funds required in the 20 year projection period. Should biomass be available at no cost and did not require chipping, it may become competitive with diesel systems. The following Table examines the economics of this situation.

TABLE 6-2: BIOMASS CONVERSION - FREE BIOMASS, NO CHIPPING

Item	Present Value ($1,000's)
1. Fuel preparation & handling	
- fuel bin	10
- chip outfeed conveyor	12
2. Primary Conversion - no change	136
3. Heat Rejection - no change	36
4. Secondary Conversion - no change (turbine)	50
5. Peripheral equipment	10
6. Other Capital Costs	325
7. Maintenance	119
8. Labour - minus yard maintenance	1428
9. Biomass - increased efficiency to 28% therefore annual fuel requirement is 470 cords	no cost
TOTAL:	$2,126,000

Should the price of diesel fuel rise as in the high case scenario, then the biomass system would be competitive with diesel systems (i.e. $2,126,000 vs. $2,170,000 respectively).

6.2.3 Manual Feed - Biomass Purchased

In this scenario, biomass is fed to the boiler in conventional firewood sizes. The entire front end of the biomass conversion system is eliminated, but the yard man is still retained. Costs are illustrated in Table 6-3.

TABLE 6-3: BIOMASS CONVERSION - BIOMASS FEED, BIOMASS PURCHASED

Item	Present Value ($1,000's)
1. Fuel Preparation & Handling - tractor, balance eliminated	30
2. Primary Conversion - no change	136
3. Heat Rejection - no change	36
4. Secondary Conversion - steam turbine	50
5. Peripheral Equipment	10
6. Other Capital Costs	325
7. Maintenance	119
8. Labour	1666
9. Biomass - increased plant efficiency to 28%, therefore annual fuel requirement is 470 cords	322
TOTAL:	$2,372,000

This option is not as competitive as the option where biomass is supplied free of charge already in the form of chips.

6.3 BENEFIT/COST ANALYSIS

6.3.1 Anticipated Costs

The costs used in this calculation are for a biomass conversion system incorporating a chipper and automated feed system. It is this conversion process which is applicable to the community of Trout Lake. These costs are $3,244,000 and $3,186,000 respectively for systems with steam engines or steam turbines. It may be found that an additional expense of $200,000 will be needed to purchase and operate a small diesel generating system and related interface controls to meet peak demand during the projection period. Using the average cost

for the two systems and adding the stated additional costs, the total costs are $3,415,000.

6.3.2 Anticipated Benefits

The benefits of using a biomass conversion system in relation to a diesel generator accrue to having capital retained in the community and replacing oil derived fuels with renewable resources. Each benefit is listed below with an explanation of how the present value was calculated.

6.3.2.1 Increased Employment

In total, 7.4 man years of employment would be created each year by using local labor to operate the plant and harvest biomass. If each position was filled by someone directly or secondarily receiving social assistance, approximately $850/month/person would be saved. These figures equate to an annual saving to the funding agency of $75,000. The present value of these savings over 20 years assuming 5% escalation in social assistance contributions per year and a discount rate of 12% equates to $892,000.

6.3.2.2 Employment Multiplier

The increased capital flowing into the community would create a demand for goods and services not provided presently. Including the capital paid for harvesting and delivering biomass to the plant, $171,000 would be introduced the first year into the community. If the individuals now employed were

receiving social assistance prior to working at the plant, an additional $96,000 would be entering the community. If one assumes an employment multiplier of one additional job being created for every three offered because of the plant, then the savings to the social assistance funding agency would be $303,000.

6.3.2.3 Motivation Factor

As discussed in the impact assessment a positive benefit can be expected by introducing this technology into Trout Lake. With the high unemployment rate and large population of young residents, knowing that potential employment may be available that demands technical skills could motivate specific individuals to pursue post-secondary education. The savings totalled from one individual becoming motivated every 2.5 years (8 people in total) and not remaining or depending on social assistance equates to $458,000.

6.3.2.4 Replacement of an Oil Dependent Technology with a Renewable Energy Source

The savings that can be attributed to going off-oil are the costs of purchasing that displaced oil. If $200,000 is necessary to purchase diesel for the peak load generator, then the savings are $1,400,000 (reference case).

6.3.3 Benefit/Cost Calculation

As derived in prior sections, the total costs and benefits are:

Costs: $3,415,000

Benefits:

- increased employment	$ 892,000
- employment multiplier	$ 303,000
- motivation factor	$ 458,000
- off-oil	$1,400,000
TOTAL:	$3,053,000

The net sum of the benefits and costs are minus $362,000.00 If the high case is used for the price of diesel, total benefits become $3,253,000. In this latter scenario, the net sum equates to minus $162,000. Revenue generated by sales is excluded from benefits as this information is confidential. It is estimated that total sales over the 20 year projection period will amount to at least $300,000. Given that this figure is an order of magnitude number and is subject to variation, it appears that the project results in net benefits as oil prices tend to escalate towards the high case scenario. The following table examines benefit/cost ratios for the community of Trout Lake taking into consideration various oil price escalation scenarios (revenue generated by sales is included):

TABLE 6-4: BENEFIT/COST RATIOS FOR TROUT LAKE

Biomass Technology	Benefits	Costs	Benefit/Cost Ratio
- Chipper with automated feed system			
- Oil price escalation:			
1) Low	$2,883,000	$3,415,000	0.84
2) Reference	$3,353,000	$3,415,000	0.98
3) High	$3,553,000	$3,415,000	1.04

Benefit/Cost ratios tend to be greater than 1.0 should oil prices escalate at rate just above the reference case (i.e. 1.5% real escalation).

7.0 IMPACT ASSESSMENT

When defining the potential impacts of introducing biomass generating technologies into remote communities, two factors must constantly be weighed against each other - the overwhelming support for job opportunities versus the provision of an essential service. In the report, Socio-Economic Overview of Northern Alberta (NADC, April 1981), unemployment rates for native populations are cited as being as high as 70% to 80%. Given this climate, any potential employment opportunities are well supported. But, the provision of electricity is an essential service. This fact is reflected by the strict regulations stated in the Hydro and Electric Energy Act. Therefore, the examination of potential impacts and support for the project are viewed in the context that electricity production can not be interrupted.

The impacts which can be created by development in communities with high native populations are numerous. Consider the examples shown in Table 7-1. It is within this general environment, that this project must be developed. These concerns and others are addressed in this Chapter with regards to Trout Lake and Garden River, Alberta, although they could apply generally to other similar communities.

7.1 Ideological Acceptance

Being a renewable energy technology, generating electricity with biomass is not very far removed from existing

TABLE 7-1: THE IMPACTS OF DEVELOPMENT ON NATIVE POPULATIONS

Conditions	Effects	Needs
- possible pollution/ destruction of natural food supplies	- more impact on non-Native population	- compensation for trapline destruction
- trapline destruction	- few Natives have been able to take advantage of employment and business opportunities	- affirmative action program
- unemployment rates 70 - 80%	- culture shock	- employment program which includes identification, recruitment placing and follow-up
- those Natives employed are at low levels	- disruption of Native lifestyle	- flexibility re hours off to trap
- limited services	- loss of direct or secondary income	- rotational work force
- lack of skills for wage economy	- loss of family security	- relocation assistance
- labour often imported rather than local	- alcohol and drug abuse	- affordable, high quality housing
- forced to relocate to be employed	- no voice in community affairs	- adult education facilities
- lack of amenities	- fear of being "squeezed out"	- daily mail and telephone service
- lack of local govt.	- high turnover of Native staff	- upgraded roads
- lack of sewage, running water	- do not meet minimum educational qualifications for employment	- "on-the-job" training
- lack of local leadership development		- locally available union memberships
- no funds which may be used to improve communities at community discretion		- functioning social and recreational activities
- lack of land tenure		- sewage, running water
- women unable to participate without daycare		- alcohol and drug abuse problems
- few people own businesses		- resource people for leadership development
- programs of colleges not responsive to Native community		- land tenure program
- high drop-out rates among students from grade 6-12		- day care centres
- lack of understanding of trade unions		- Native industrial co-ordinator

Derived from the content analysis of the interventions made in Fort McMurray during the 1979 E.R.C.B. Hearings on the Alsands Tar Sand application.

beliefs held by the communities. Isolated life styles are dependent upon a high degree of self-sufficiency. Repair to residential structures, machinery, and water systems are often undertaken by the household. Survival is dependent upon the individual managing their own affairs to ensure that needs are met each year.

A good example of ensuring resources are not depleted is the way a trapper maintains his trapline. Over-trapping will result in less or no income from that trapline the next year. Another example is how the communities currently harvest firewood. Different locations are used, therefore, one area is not over harvested.

Introducing a biomass generating system into a community results in residents becoming involved in the entire chain from generating to consuming electricity. The entire process is retained in the community. The overwhelming need for local employment provides initial support for the project, but the project must be well organized and implemented for it to be successful and to thus increase residents' pride in the community.

7.2 Community Relationships

There are two perspectives which can be used to judge changes in community relationships. Changes are caused by either external or internal pressures. Relationships with neighboring communities should not change to any great extent.

This can be supported by prior projects undertaken in neighboring communities. Peerless Lake is currently building a fishing lodge. In 1979, the Trout Lake Community Association, in a brief forwarded to the study team by the Alberta Native Affairs Secretariat, expressed an interest in developing a fishing lodge in their community. Although residents of Trout Lake mentioned the building of the Lodge at Peerless Lake, they seemed not to harbour any discontent.

Should the project go ahead, a positive impact may occur. The transfer of biomass generating technologies to other communities would be dependent upon the success of the project at the recipient community. Therefore, other communities could exert pressure on local residents to ensure the project is successful.

7.3 Skill Levels

According to questionaires, the majority of adults within the communities have not completed high school. For those adults who have attended university, they are most likely the teachers who are term residents in the community. Albeit the level of education is not as high as found in non-remote communities, a more appropriate examination of available skills is one that focusses upon the tasks required to enable a successful project. These tasks include:

(1) Biomass harvest and delivery;

(2) Forestry management techniques;

(3) Business management;

(4) Construction;

(5) Plant operation.

The labour pools in communities such as Trout Lake and Garden River are restricted in skills and numbers. Instead of being able to recruit manpower with the required skills, one is often forced to seek an individual who, with subsequent upgrading, is interested in undertaking the position. Problems finding this type of individual have been mentioned by Northlands School Division and Improvement District 17. This is not to say that manpower is unavailable, only that the implementation of a project such as being examined in this study, may involve considerably more lead time than similar projects in relatively urban areas.

The current level of skills pertaining to the aforementioned tasks are discussed below with suggestions as to how the upgrading of required skills can be undertaken.

7.3.1 Biomass Harvest and Delivery

Since wood or biomass is the primary method of space heating within the communities, sufficient skills are present to undertake this task. Residents are familiar with the operation of chainsaws and related equipment to a good extent. Should horse logging be employed, these skills can also be found in Trout Lake.

7.3.2 Forestry Management Techniques

Although current wood cutting follows rudimentary forestry management techniques, skills relating to this area need to be upgraded. Managing 36 square miles (the area necessary as discussed in Chapter 4) of forest to enable sustained yield involves skills pertaining to proper harvest management, the building of skid trails, reforestation techniques etc. The Community Vocational College could possibly be the agent for providing upgrading in this skill area.

7.3.3 Business Management

There are individuals currently residing in each community with management skills; however, these individuals tend to be employed. Therefore, upgrading in this task area will be required. Given that most of these skills would relate to managing the biomass harvest and delivery mechanism, a high level of sophistication would not be needed. Again, this skill upgrading could possibly be delivered by the Community Vocational College.

7.3.4 Plant Operation

Since gasification has not demonstrated continuous operation, the proven technologies than can be applied to Trout Lake and Garden River rely upon steam power plants. The size of boiler applicable for meeting power demands requires a

Fourth Class Certificate for general supervision and a Fireman's Certificate for continuous supervision (see Table 2-6). It is assumed that one operator can maintain the plant in this scale of operation. Currently, there are no residents in the community with these qualifications. However, there are residents who have some related aptitudes and may be interested in obtaining these skills.

Of prime consideration is the individual who requires the Fourth Class Certificate. This individual would have overall authority for the plant's operation. Although it is possible for a current resident to attend a vocational institution for one full year and obtain this certificate, they would have no practical experience in the field. This project, being a demonstration of biomass conversion technologies, would require an appropriate level of knowledge to troubleshoot the system as required and keep accurate records for further study. Therefore, it is suggested that this individual be brought into the community to initiate the project and train plant operators.

The fireman's certificate does not involve the combination of credentials and experience required for the Fourth Class Certificate. Temporary certificates can be issued by the Alberta Boilers Branch with the provision that the exam be written and passed within six months. An individual with 12

months experience as a fireman can obtain a Fourth Class certificate by passing the required examination.

By bringing in a qualified individual with a fourth class certificate or better, on-the-job training can be provided to plant operators. These plant operators who have obtained Fireman's Certificates can in the future obtain the Fourth Class certificates. Once this level of competency has been achieved, the original plant general supervisor can be replaced.

Although other ways exist in which to fill the positions of plant operators, this method is suggested as it involves little or no necessity for residents to leave their community. It has been mentioned that there may be individuals who would leave the community for training, but interest lessens as the length of absence increases.

7.3.5 Construction

Experience gained from the housing replacement project conducted by the Opportunity Corps in Trout Lake has resulted in the availability of a local labor pool that can construct the building encompassing the plant with minimal skills upgrading. Although no similar organization exists in Garden River, the project team saw local residents building residences during their visit to the community.

7.4 Outside Labour Force

Should outside personnel be brought in to develop and or operate the plant, minimal impact is expected as long as these individuals remain civilized. Resentment may result if tasks are being performed by outside personnel that could be undertaken by local inhabitants. The community is accustomed to certain numbers of outsiders entering the community on a temporary basis as was the case when the new schools were built in both communities.

7.5 Demand for Supplies and Services

Should outside labour be brought into the community, adequate housing does not exist in either location. Two alternatives are possible: first, stay at Red Earth or High Level and commute; second, bring in temporary housing. It is suggested that the latter alternative be considered for the distance from Red Earth and High Level to the respective communities is considerable and the road is not always easily passable. Plus, no food services besides the store are available in the communities. Again, as local residents state, if these outsiders remain civilized, no problems should occur. It must be realized that the services available in Trout Lake and Garden River are minimal at best. Demand for certain services may increase such as a central water system, but as the accommodation would be temporary, it is perhaps best for the construction camp to provide its own services.

7.6 Environmental Impact

There are three areas of environmental concern: the forest area set aside for harvest, the location of the plant, and the technology of the plant.

Regarding the area necessary for harvesting biomass for the plant, conflict with other land uses and wildlife could result. However, with proper and effectively managed harvesting methods, the impact should be minimal. Consideration will have to be given to traplines within the area and recognition that local residents may also be currently using that location for collecting domestic firewood. On this latter point, roughly the same area set aside for the plant will be needed to meet the community's requirement for firewood.

The location of the plant, in many respects, is dependent upon the conversion technology. Should it be found necessary to use an open steam generation system, access to large bodies of water is essential. In addition, the location of the plant may necessitate incorporating the existing location of the diesel generating system and the layout of the community.

As mentioned earlier, in Garden River, the location must be approved by Parks Canada and the Federal Cabinet. In Trout Lake, the location of the plant would be subject to the community's approval as the community currently has a crown lease for 680 acres upon which Trout Lake is developed. It is

suggested that once approval from the Trout Lake community has been granted, Alberta Energy and Natural Resources should exempt the property from the community and lease it directly to the plant authority.

As far as pollutants from the plant are concerned, if they are not kept down to the levels prescribed in the Clean Air and Water Acts, the plant will not receive approval from the ERCB. However, these regulations do not address noise pollution. The chipping operations in a biomass conversion system are extremely noisy. In order to reduce the noise impact, the process must somehow be enclosed to reduce sound transmission to the community at large.

7.7 Future Impact

There are two general areas of concern regarding long range impacts if this project is undertaken. The first area deals with changes in the community's attitudes towards workers actually operating the plant. The second impact concerns changes in the socio-economic environments of the respective communities.

A demonstration project such as the one being examined in this study involves various government agencies and Alberta Power. At the onset of the project, the respective roles of these agencies will be generally recognized by the residents from the community. But, as the project progresses and if it is found to be successful, virtually the entire process of

generating and consuming electricity will take place within the community. Thus it is possible for area residents to begin to believe they own and operate the system. Problems internal to the community could arise regarding energy charges and other associated items. Therefore, it must be made very clear from the beginning, what are the long term and ongoing roles of the various agencies.

Should such a project be integrated into a community, the long-range, socio-economic impacts would tend to be positive. Not only would employment opportunities be created directly from operating the plant and harvesting biomass, a further multiplier effect could occur as the increased capital flowing into the community would create demands for additional services and goods. Thus, additional employment could be created.

Another positive benefit is the effect the project would have on the youth of the communities. Knowing that there is the likelyhood of future employment, they would be encouraged to pursue technical education that relates to various functions inherent in the conversion process. Forest and business management skills, plus the technical expertise of operating the plant are just several of the skills that are needed. As employment is created, there is the potential of not requiring social assistance for those individuals who have found employment.

It is possible for impacts to be negative; but it is perceived that these impacts would tend to be more socially oriented than technologically related. Many of these items are listed in Table 7-1. Recognition of these potential problem areas at the start will help decrease potential negative impacts.

7.8 Project-Development/Delivery

In discussing this project with officials and representatives of various agencies and members of the communities, all showed an interest in the project. But, although all individuals were optimistic, concern was expressed by those individuals involved with non-social or non-human resource related agencies. For example it takes local labor at least three times as long to complete construction projects as outside labor. Given this environment, if local labor is to be used for the bulk of a project implemented in any remote northern community in Alberta, considerable lead time must be allowed. Relating back to the project examined in this study, this lead time can also be used to integrate the community into the project in order to clearly make it understood what are the parameters of the project.

There is also the potential problem of not obtaining a dependable labor force. This is a serious problem especially when one considers that the production of electricity is an essential service. In discussing various labor scenarios with

individuals knowledgeable with northern communities, it was suggested the best option was to hire a full complement of employees, and then provide alternates or back-ups who could be called upon when needed. It was also suggested that the labor force represent the local population of treaty and non-treaty residents.

In summary, the following conditions and criteria are worth noting:

(1) It is believed a project of this nature will be accepted by the community;

(2) Community relationships should not change significantly;

(3) Skills must be upgraded to some degree in all functions. A serious inadequacy is present in both communities relating to the operational knowledge of steam generation systems. It is suggested outside labor be brought in initially to train and upgrade local residents instead of sending them away from the community for upgrading;

(4) No problems should arise from bringing in outside labor provided that there are no personality clashes with the community;

(5) Should an outside labor force be brought in, it is suggested that they supply their own housing facilities as local services are minimal;

(6) Two potential land use conflicts may exist depending upon where the biomass harvest areas are designated, e.g. trapping and firewood harvest. Initial planning should ensure these conflicts will not arise;

(7) The plant design must lessen the effects of noise pollution on the community;

(8) A misunderstanding of the project at the onset could lead to misconceptions in the future on the behalf of local residents as to who actually owns the plant;

(9) It is anticipated that the project, with proper implementation, will have generally positive benefits on the recipient community. These benefits include additional employment opportunities, an example to the community's youth, and less future dependance for social assistance;

(10) Considerable lead time may be needed to develop the project. This time could be used to ensure that the project's parameters are understood locally and that future potential problems are addressed before they become paramount;

(11) It is suggested that a full labor complement be hired to operate the plant with designated alternates or backups provided to ensure plant operation is not interrupted. The labor force should reflect the community's treaty and non-treaty residents.

8.0 CONCLUSIONS AND RECOMMENDATIONS

In conclusion, considering that the above project is highly desirable from the employment, skill creation point of view, and the reduction of dependance on a non-renewable resource we recommend that implementation be considered at a location similar to the above two communities that can provide free biomass. This recommendation is based on fact that the present value of a diesel system is comparable to the present value of a boiler/steam engine (turbine) system using free biomass and no chipping.

Implementation of the above pilot project would have the advantage of evaluating integration of the project without costing the taxpayer too much money. (There is less than a 10% cost difference between the present values of these two alternatives. It is also believed that a community of larger size could provide economies of scale to make it all worthwhile.

APPENDIX I

RCDP Reference List

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APPENDIX II

CONVERSION UNITS

1 cord stacked (128 cu. ft.)	= 3.6246 m^3
1 cord solid (85 cu. ft.)	= 2.407 m^3
1 cord stacked/ha	= 8.956 m^3
1 cord solid/ha	= 5.91 m^3
1 cord solid wood	= 2407 kilo green (1) av.m.c.

NOTES ON MOISTURE CONTENT CALCULATIONS

Various publications on biomass conversion refer to o/o of moisture and have been calculated in two different ways. Care must be determined to ascertain which method of calculation is used. Two references researched revealed contradictions.

The standard method of moisture content calculation is: -

$$o/o = \frac{\text{Green weight - Dry Weight}}{\text{Dry Weight}}$$

however in some instances, moisture content calculation used is: -

$$o/o = \frac{\text{Green weight - Dry Weight}}{\text{Green Weight}}$$

SOURCE:

Manufacturing operation scale data on bucked to length short Aspen/Poplar logs. Environment Canada 1974. Selected (51) metric units & conversion factor for Canadian forestry. Canadian Forest Service, Ottawa.